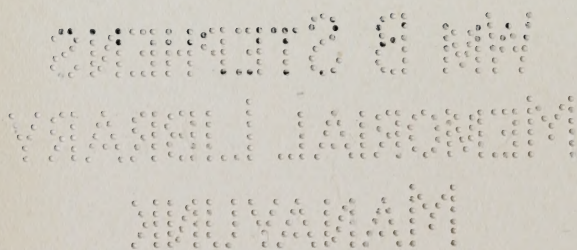


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THE CHEMISTRY AND PRACTICE
OF SIZING.

NINTH EDITION (AMERICAN).



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THE CHEMISTRY AND PRACTICE OF SIZING.

A Practical Treatise on
THE SIZING OF COTTON YARNS,
PRACTICAL SIZE MIXING,
TAPE SIZING, BALL OR WARP SIZING, AND HANK SIZING.

WARP BLEACHING AND TINTING. HANK BLEACHING.
MILDEW AND IRON-STAINS.
CLOTH BLEACHING.
THE VENTILATING AND HUMIDIFYING OF WEAVING SHEDS.

BY

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AND

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NINTH EDITION (AMERICAN).

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1911

PREFACE TO THE NINTH EDITION.

THE First Edition of this book was published in January, 1903, and it was immediately followed by an edition specially printed for India. These two editions were sold out within twelve months of publication, and, although the demand for the book was sufficient to warrant a third edition, the writer was unable to meet the requirements because he was engaged at the time in publishing "The Chemistry and Practice of Finishing."

The third edition of the book was published on October 1st, 1906, followed by editions for the United States of America and for the Continent.

The present (ninth) edition has been completely re-written and much new matter incorporated. The practical portion on Size Mixing, Tape Sizing, Warp Sizing and Hank Sizing has been dealt with much more fully than previously, and a new portion dealing with Warp Bleaching and Tinting, and Hank Bleaching has been added.

Mr. Fred Scarisbrick of Darwen has again collaborated with me in the chapter on Tape Sizing. He has also supplied certain special matter in

connection with a series of personal experiments conducted with the aid of Dr. Howarth, Medical Officer of Health for Darwen, for the purpose of showing the effects of working in an atmosphere having a high "wet bulb" temperature.

I have to acknowledge the services of Mr. Dan Scholefield for much valuable assistance in regard to the practical side of Ball and Hank Sizing and Bleaching.

I beg to record my thanks to the firms who have so kindly assisted me in the production of the book by supplying the blocks for the Machinery illustrations, etc.

PERCY BEAN.

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January 2nd, 1911.

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INTRODUCTION.

SIZING is the most important preparatory process to which cotton yarns are subjected previous to their being woven into cloth. It is one of the operations in manufacturing which requires sound judgment as well as manual dexterity on the part of the operative. More than this, it is necessary for the manufacturer, or his manager who is really responsible for the sizing, to possess sufficient chemical knowledge of the various substances used in sizing to get the best results at the lowest possible cost. It is remarkable that, until quite recently, so little importance has been attached to the necessity of acquiring the chemical knowledge so essential to the successful carrying out of the operations upon which so much of the success of the after process of weaving depends.

If cotton manufacturers, or their managers, possessed as much knowledge of the chemical properties of the materials used in sizing, as they do of the other details of their business, there would be

no need for such a work as this. But so long as the study of chemistry is not considered an essential part of the training of a cotton manufacturer, so long will the results obtained in sizing be matters of chance.

There is no doubt that the losses suffered in the past, and the losses still being suffered, are due in many cases to the absence of expert knowledge of the properties of the various substances used as ingredients of size, and these losses might have been, and may be, avoided by a knowledge of chemistry. Not only should the manufacturer possess chemical knowledge in order to prevent damage to his cloth, but he should be able to apply this knowledge in order to place his sizing on the most economical basis. It is astonishing to find men, who can see at once the advantage of being up-to-date with their machinery, adhering to old and wasteful methods in their sizing. This conservatism is due almost entirely to the fact that they do not possess sufficient chemical knowledge to make alterations in their sizing arrangements, whereas they are perfectly familiar with the machinery used in their business. Consequently they are in a position to appreciate anything which is an improvement in machinery, but fear to make alterations in their sizing. Many of the leading manufacturers would be astonished at the amount of saving which could be effected in their sizing, if they could only be

persuaded that the results they get, could be obtained, equally well, at a very much less cost. The excessive cost of many sizes is due, in the first place, to the fact that manufacturers continue to use secret preparations, which are sold to them at prices much above the actual value of the ingredients used in their preparation, and in the second place because they continue to use ingredients which are incompatible, and therefore utterly useless when mixed together. In fact they are generally worse than useless inasmuch as they are positively wasteful. Many of the mixings which some manufacturers pride themselves upon as being superior to anything possessed by anyone else have been built up in the most haphazard way. Probably in the first instance the mixing consisted of the ordinary ingredients, such as flour, starch, China clay, tallow, chloride of magnesium, and chloride of zinc. Then someone, with special abilities as salesman, has persuaded the manufacturer that the addition of some particular article would bring about some wonderful result. This particular ingredient has been then added to the size, and later someone else has persuaded him that a special preparation of his own is the one thing required to make the mixing a perfect size, and this also has been added. So it has gone on, until, in time it has been forgotten how it came to pass that a mixing contains a dozen ingredients instead of about half that

number. The curious thing is that if the manufacturer only knew the composition of the various mysterious ingredients he is using, he would find that they were similar to those in general use, excepting that they contain large quantities of added water. It is when the origin of a mixing has been forgotten that the manufacturer believes that he possesses something of very particular value not possessed by other manufacturers, whereas any and every mixing in use to-day could be matched with a choice of materials ranging not more than about half-a-dozen in number. Manufacturers rarely consider to what an extent they place themselves in the power of individuals when they persist in the use of secret preparations. There is also the possibility that the particular ingredient is not only absolutely wasteful, but it may be actually an injurious substance to use with other ingredients. As a matter of fact the authors know of many cases of damage caused by the use of certain substances which by themselves have no injurious properties. A manufacturer is therefore well advised to keep his size mixings as simple as possible, and use only those substances, the composition of which is known to him.

The sizing of yarns dates back as far as we have any history of woven cotton goods. As first practised in Lancashire, sizing consisted in passing the threads of warp through some adhesive substance,

such as flour paste, and afterwards drying them. This gave the threads the necessary strength, but they were too harsh for successful weaving. To reduce this harshness, and at the same time make the yarn more pliable, tallow or oil of some description was added to the mixing, and this gave all that was requisite for successful weaving.

Later, sizing was carried out with the idea of producing goods which should possess a certain feel in the grey state. These goods were not intended to be bleached, but were intended to be sold and used in the grey state only. About this time heavy sizing also began to be largely practised, and many substances came into use which had not been in use previously. Amongst these was chloride of magnesium, a substance which was added to the size for the purpose of softening the yarns and also for improving the weaving. It was an ideal substance for the purposes mentioned, but it possessed one feature which produced effects which were never anticipated at the time. Chloride of magnesium has the power of absorbing moisture, hence its effect in strengthening and softening the yarn. But this absorption of moisture also has the effect of making the starch in the size a suitable medium for the development of mildew growths. The results were disastrous when the goods were shipped abroad. Mildew was developed during the passage out, and many thousands of pounds were lost before

antiseptics, such as chloride of zinc, etc., came into general use. This is a typical instance of the evil results which may accrue through using a substance, the nature of which is totally unknown to the user.

It was about this time that heavy sizing became very greatly abused. The sole object some of the manufacturers seemed to have in view, was how to make cloth with as little cotton and as much size as it was possible to incorporate together. This heavy sizing was carried on without sense or reason and many manufacturers paid very dearly for the experience they got.

For the last twenty or thirty years heavy sizing has been carried on in a perfectly legitimate manner. There is a demand for cheap cotton cloth for certain purposes, and this demand can be met only by sizing. Such cloth is sold in the grey state. It is never washed, but used in the condition in which it is received. It is still customary, however, for persons unacquainted with the cotton trade to condemn the policy of Lancashire cotton manufacturers in making heavily sized goods for export. These people still believe that the sole object of sizing is to defraud the natives who purchase the cloth, whereas the natives know perfectly well what they are getting, and there is no question of their being imposed upon. As a matter of fact heavily sized goods are more suitable than pure calico for many purposes.

It would be a very unfortunate thing for Lancashire if the demand for heavily sized goods should cease, unless the natives of India and China were able to pay the additional price for pure cotton cloth. It is a matter of common knowledge, however, that heavy sizing is generally on the decrease, and this is due, in the authors' opinion, to the fact that the world is becoming richer, and people are now able to purchase more highly priced goods than they were formerly in a position to purchase.

SUBSTANCES USED IN SIZING.

A large number of substances have been introduced for sizing purposes at one time or another. Some of them have stood the test of time, whilst others have been short lived. There are three important points to consider when determining the value of a substance to be used for sizing. In the first place it must be low in price. In the second place it must have no detrimental properties as regards its action on the weaving. In the third place it must be free from injurious impurities or latent defects which would cause damage to the cloth after it is woven. The following list of ingredients includes practically the whole of those in regular use at the present time, and they may be divided into five great classes, viz. :--

1. FOR GIVING ADHESIVE PROPERTIES TO THE SIZE.

Wheaten Flour
Farina (Potatoo Starch).
Maize or Corn Starch.
Sago.
Rice Flour.
Rice Starch.
Tapioca.
Dextrin.
Soluble Starch.
Iceland and Irish Moss.
Apparatine.
Gum Tragacanth.
Gum Tragasol.

2. MATERIALS FOR GIVING WEIGHT AND BODY TO THE SIZE AND YARN.

China Clay.
Sulphate of Magnesium (Epsom Salts).
Sulphate of Calcium (Sulphate of Lime or Gypsum).
Sulphate of Soda (Glauber's Salts).
Sulphate of Barium (Barytes).

3. MATERIALS FOR "SOFTENING" THE SIZE AND YARN.
(*Direct Softeners*).

Tallow of various kinds.
Palm Oil.
Castor Oil.
Cotton Seed Oil.
Oleine Oil (Alizarine Oil or Turkey Red Oil).
Cocoanut Oil.
Soluble Oil.
Stearine.
Paraffin Wax.
Japan Wax.
Spermaceti.
Soap of various kinds.
Glucose.

4. MATERIALS FOR SOFTENING AND GIVING WEIGHT TO THE SIZE AND YARN. (*These substances act as softeners by absorbing moisture, and so produce good weaving*).

Chloride of Magnesium.

Chloride of Calcium.

Glycerine.

5. FOR PRESERVING THE SIZE FROM MILDEW AND DECOMPOSITION.

Chloride of Zinc.

Carbolic Acid.

Cresylic Acid.

Salicylic Acid.

Glycerine.

Thymol, &c., &c.

From what has been said already it will be seen how very necessary it is that manufacturers should arrange to have their sizing ingredients tested or analysed. This should be done for three reasons: firstly, to ascertain whether they are free from adulteration or injurious impurity; secondly, whether they are equal in quality and strength to the samples originally submitted by the dealer; and thirdly, whether they are equal to those previously in use.

With this object in view it has been considered advisable to give details of the various tests and methods of analyses used in the Laboratory, many of which may be made by men who have received no chemical training whatever.

In a work of this description the authors have to face two difficulties. In the first place it is necessary

to cater for the requirements of the practical man whose knowledge of chemistry may be nil. In the second place, the book is written for the use of students who have had the benefit of some chemical training at one or other of the Technical Schools. To neglect the description of the chemical apparatus used in making the various tests hereinafter described, would be to fail in a matter most essential to the practical man who desires to obtain the required knowledge, whilst the risk remains of wearying those students who have got past the need of such details. In the face of such a position the authors feel justified, in spite of the fact that they lay themselves open to adverse criticism on the grounds that the subject is one for an elementary text book on chemistry, in giving full details of many simple tests, and also a full description of the chemical apparatus necessary to carry out these tests. That this matter may not be a constant source of irritation to advanced chemical students, the authors propose to discuss this portion of the subject in the introductory part of the book, by this means keeping the elementary description in a place to which easy reference may be made at a later stage. This will prevent many needless repetitions in the description of the tests, and whilst avoiding wearying one class of students, will not be neglecting the interests of the other class.

The following is a list of some of the most

important pieces of apparatus which the manufacturer's laboratory should contain, a detailed description of which is given later :—

- Chemical Balance.
- Set of Weights (Metric).
- Microscope.
- Steam-bath or Drying Oven.
- Water-bath.
- Bunsen's Burners.
- Retort Stand with rings.
- Mortar and Pestle.
- Platinum Crucible.
- Porcelain Crucibles.
- Iron Wire Triangles.
- Crucible Tongs.
- Test Tubes.
- Test Tube Stand.
- Funnels.
- Filter Papers.
- Nest of Lipped Beakers.
- Nest of Round Beakers.
- Porcelain Evaporating Basins.
- Cylindrical Test Glasses.
- Watch Glasses and Clip.
- Thermometer Fah. 212°
- Thermometer Fah. 600°
- Hydrometers.
- Blue and Red Litmus Paper.

Other apparatus may be added according to the requirements and advancement of the reader, but the above list includes all that is necessary to make any test likely to be undertaken by the practical man, and indeed many valuable tests may be made when the operator possesses only a few test tubes, beakers, and evaporating basins.

The following list of Chemicals or Reagents will be required, and should be stored in six or eight ounce stoppered bottles, properly labelled.

SOLUTIONS.

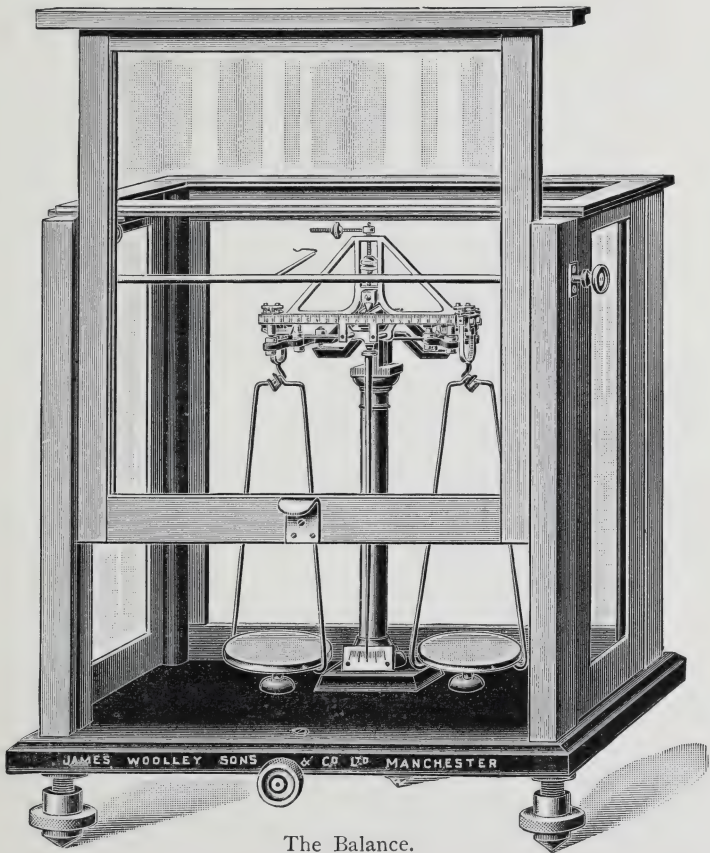
Dilute Hydrochloric Acid.	
Strong Hydrochloric Acid.	
Dilute Sulphuric Acid.	
Strong Sulphuric Acid.	
Strong Nitric Acid.	
Solution of Ammonia.	
„ „ Ammonium Chloride.	
„ „ Ammonium Oxalate.	
„ „ Ammonium Carbonate.	
„ „ Ammonium Sulphide.	
„ „ Ammonium Phosphate.	
„ „ Ammonium Molybdate.	
„ „ Caustic Soda.	
„ „ Barium Chloride.	
„ „ Silver Nitrate.	
„ „ Iodine.	
„ „ Ferrocyanide of Potassium.	

The above solutions may be bought ready prepared and of the right strength, or the solids may be obtained, and dissolved in distilled water. Where large quantities are used the latter method is the cheaper, but the manufacturer will probably find he has less waste by getting the solutions. Other chemicals are mentioned under certain tests in the text, and where these tests are made it will be necessary to obtain them.

THE BALANCE.—The balance is a most essential piece of apparatus in a manufacturer's laboratory, and very little practice is necessary

to enable anyone with moderate ability to use it successfully.

The instrument consists of a rigid metallic lever or beam, suspended, near its centre of gravity, on a



The Balance.

fulcrum or pivot; the masses to be weighed or compared being also suspended from pivots placed at the extremities of the beam, equidistant from, and in the same perpendicular plane with the central

fulcrum. The beam has the shape of an acute rhomboid; this particular form combines lightness with rigidity and strength. On the possession of these qualities depends the sensibility of the balance. Through the centre of the beam passes a triangular piece of hardened steel, or agate, termed a knife edge, the lower edge of which turns upon a horizontal plate of polished agate connected with the pillar. At the end of each arm is a similar knife edge fixed in the reverse position, and bearing an agate plate from which depend brass or steel hooks to hold the pan suspensions.

The terminal knife edges are fixed in brass settings and admit of being adjusted so as to bring them into exactly the same plane with the middle edge. Their relations to the middle knife edge may be altered by means of the little adjusting screws at the sides.

The efficiency of the balance depends to a large extent on the preservation of the sharpness of the knife edges, and the absolute smoothness of the agate planes; it is therefore desirable to prevent their contact when the balance is not in use. This is effected by means of a frame which lifts the middle knife edge from the middle plane. At the extremities of the frame are steel points which enter into little hollows in the lower surface of the pan suspensions and raise them from the terminal knife edges. The frame is attached to a rod descending through the pillar

and connected with an eccentric, worked by a screw, with a milled-head, situated on the outside of the balance case, by means of which, the rod, and with it the frame, can be raised or lowered.

The movements of the beam are indicated by a vertical pointer which swings in front of an ivory scale fixed to the pillar. This ivory scale is graduated, usually into 20 parts, the middle point, or zero, being exactly behind the needle when the beam is horizontal. Any inequality in the weight of the arms is compensated by means of a small vane fixed on the top of the beam above the middle knife edge which may be turned to the right or left as required. The stability of the beam is regulated by the aid of a weight termed the *gravity-bob*, which can be moved along the rod attached to the upper edge of the beam, over the middle knife edge on which the vane works.

In order to protect the balance from acid fumes, etc., and to prevent air currents interfering with its action during the operation of weighing, it is enclosed in a glass case, the back, front, and sides of which can be opened at will. The case is supported on levelling screws, by which it can be adjusted to a horizontal position in accordance with the indications of the spirit level attached to the bottom of the case.

The balance should be placed in a room where the amount of vibration is as little as possible, and

should not be moved from the position determined upon. If, on commencing to weigh, the balance be found not in equilibrium, the beam and pans should be lightly brushed with a camel's-hair pencil, and again tested. Care should always be taken to close the door of the balance case after using.



Set of Gramme Weights.

THE WEIGHTS.—In all the operations of weighing described in the book, the authors have used the metric system, not only because it is the usual one in analysis but because it is the simplest, and bears a direct relationship to the standards of length and capacity.

A set of weights extending from 50 grammes to a centigramme ($\frac{1}{100}$ part of a gramme) will be found

most generally useful. Such a set should contain the following :—

Grammes.		Grammes.		Gramme.		Gramme.
50	.....	5	.....	0'5	.....	0'05
20	.....	2	.....	0'2	.....	0'02
10	.....	2	.....	0'2	.....	0'02
10	.....	1	.....	0'1	.....	0'01

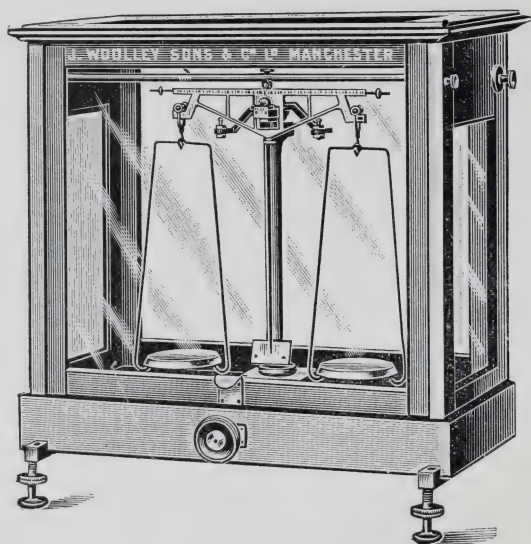
The fractions of a gramme below the second place of decimals may be obtained by the use of a rider, which is sold with the weights. This is placed on the beam of the balance. The beam is graduated into 10 divisions, each division representing 1 milligramme ($\frac{1}{1000}$ part of a gramme); these divisions are subdivided into '25, '5, and '75 of a milligramme.

In using the weights, they should be taken from the box by means of the forceps, and on no account touched with the fingers. The weights should not be used haphazard, but the one judged to be required should be put on the pan first. If it be too heavy, the next lighter one should be used, first replacing that previously tried in its proper position in the box. If this be too light, the next smaller weight must be added, and so working down to the smallest weight, and finally, by using the rider, obtaining the milligrammes necessary.

The student should not only be able to ascertain the total weights used by counting them on the pan of the balance, but he should ascertain this total, as

a check, by calculating from the empty holes in the box. The greatest care should be taken to protect the weights from the action of acid fumes and dust.

In using the balance, the object to be weighed is placed on the left hand pan facing the operator, and the weight on the right hand pan. It is more often necessary to find the weight of a substance than to weigh a certain quantity of it, consequently it is



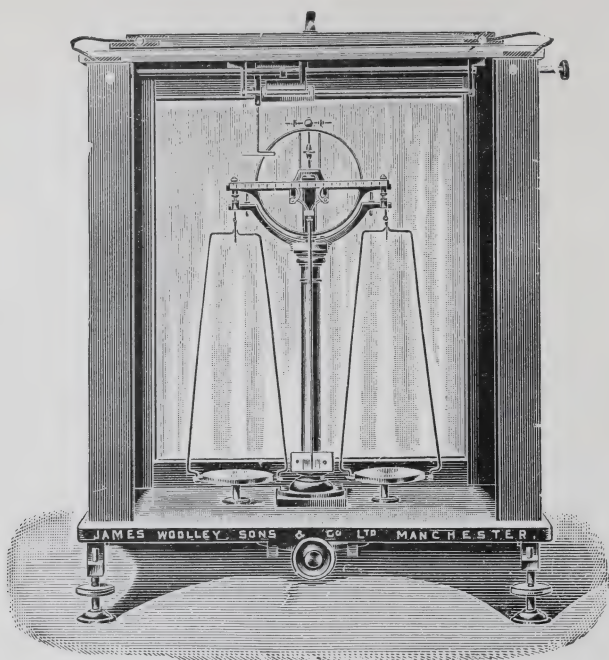
Woolleys' Balance.

easier to place weights on the right hand pan than on the left. This method of weighing is the reverse of that which is usually practised with ordinary scales and weights.

It must be carefully borne in mind, that, whenever a weight is put on or withdrawn from the pan the motion of the beam must be arrested. *Under no circumstance must anything be placed on or removed from the pans when the beam is free to oscillate.*

For commercial work it is not necessary to have the most delicate balance. Messrs. James Woolley, Sons & Co. Ltd., Victoria Bridge, Manchester, supply a very suitable one (page 18) which is known as Woolley's balance. It is contained in a glass case, having a counterpoised front sliding frame. This balance has agate knives working on agate planes, beam division, rider apparatus and two riders, improved arrestment, beam support, set-screws, and pendulum apparatus for levelling. It is made to carry 100 grammes in each pan, and turns with one milligramme. The price is £4 4s.

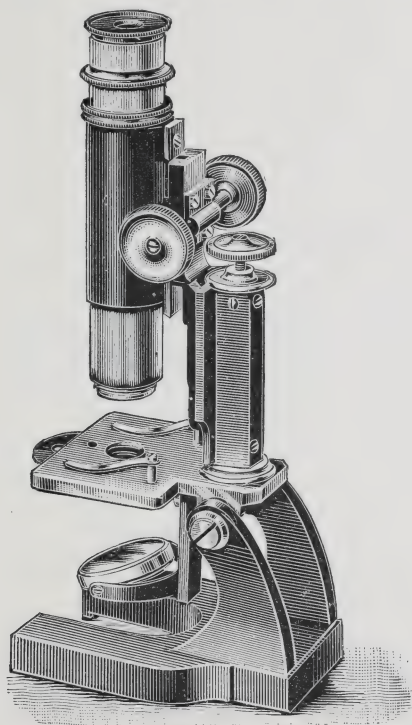
A more delicate instrument, working on a new principle, is shown on page 20. This balance carries 200 grammes in each pan and indicates $\frac{1}{10}$ milligramme. It has a gilt gun-metal beam and column. The beam is circular instead of straight, and is fitted with adjustable agate knife edges and agate planes, pan supports and arrestments for the beam and pan suspenders, rider slides, platinised pans, compensating stirrup suspenders, levelling screws and plummet. The balance is contained in a polished mahogany and glass case, having sliding windows back and



front, doors at the sides, and a black slate base. The price is £9 15s.

THE MICROSCOPE.—This very essential instrument, an illustration of which is shown on page 21, is known as the compound microscope. It is a combination of two lenses, one, acting as the object glass, being known as the objective, the other as the eye piece. They are fitted into a double tube, which admits of the motion of the eye piece so as to suit all sights. The tube is usually set nearly vertical; the object to be viewed being placed beneath the object glass at a distance a little beyond its focal distance. The rays from each point of the object collect after

refraction at a focus; the result being an inverted image of the object formed in the tube. This image is then viewed by the eye piece exactly as the original object is viewed by the simple microscope. In the best microscopes the eye piece is not a single lens, but a combination of two, the magnifying



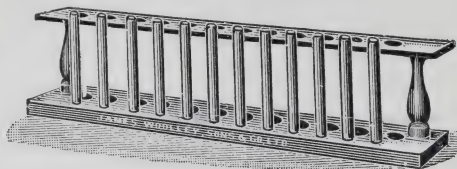
The Microscope.

The above microscope is one introduced by Messrs. James Woolley, Sons & Co. Ltd., and is suitable for any work required by the manufacturer. It has a very firm and compact horse-shoe base, and is provided with a sliding draw tube, coarse rack-work, and fine adjustments. It is inclinable, and has plane and concave mirrors. This microscope is fitted with one eye piece and two high-class achromatic object glasses, viz. :—a $\frac{1}{8}$ in., magnifying 170 diameters which can be increased to 340 diameters with the draw tube, and a 1 in., magnifying from 40 to 85 diameters. The whole is packed in a mahogany case, price £4 15s.

power of which is greater than could conveniently be obtained, on account of spherical aberration and chromatic effects, by a single lens. Achromatic arrangements are now indispensable in a really efficient microscope, in the construction of which such names as Ross, Nachel, Beck, Tolles, Spencer, Powell, etc., are world-famed.



REAGENT BOTTLES.—The most useful size has a capacity of 8 or 10 ounces. They may be obtained either with paper or white enamelled labels.

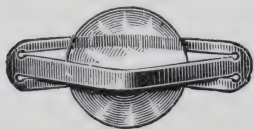


Test Tube Stand.



WEIGHING BOTTLE.—This bottle is used for weighing *dried* cotton, which must not be weighed exposed to the air on account of its power of absorbing moisture. It is furnished with a well fitting glass stopper.

WATCH GLASSES AND CLIP.—These are used when determining the amount of moisture in substances in the form of powder, such as flour and starch, etc. The watch glasses are ground to fit, so as to keep the substance free from contact with the air whilst weighing.



The following description shows the method of

using:—A pair of watch glasses and a clip are carefully weighed on the balance; two or three grammes of the substance to be weighed are placed on the lower watch glass, the upper one is then replaced and fastened with the clip, and again weighed; the increase in weight gives the amount of the substance taken.

The glasses are now carefully separated and placed in the drying oven for two or three hours, the upper glass is then replaced, fastened with the clip, cooled, and weighed again. The loss in weight represents moisture. It is necessary after the first weighing to transfer to the drying oven again for one hour; after cooling, the weight is again taken, and if it has remained constant the whole of the moisture has been removed.

The following is an example of the determination of moisture in a sample of starch:—

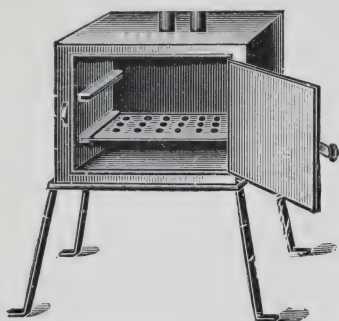
Weight of watch glasses, clip and starch...	35·348 grammes.
do. watch glasses and clip	32·417 „
do. starch taken	2·931 „

After drying:—

Weight of watch glasses, clip and starch...	34·967 grammes
do. watch glasses and clip	32·417 „
do. dry starch	2·550 „
Starch taken	2·931 grammes.
After drying	2·550 „
Loss—moisture	0·381 „

Thus 2·931 grammes contained 0·381 gramme of moisture.
This calculated a percentage gives 12·99% of moisture in the sample.

STEAM BATH.—This bath or oven is a double cased box, made of copper; the space between the two cases is filled with water, and is heated by means



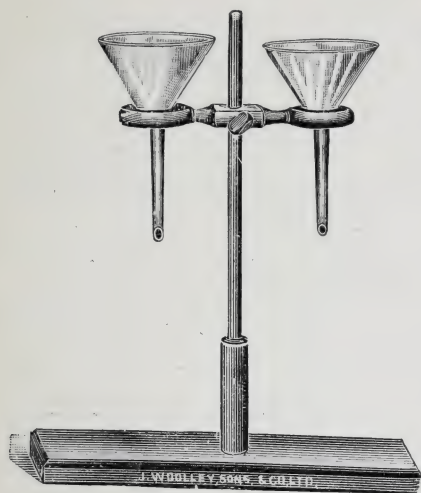
of the Bunsen's flame. The steam is either allowed to escape at the top, or conducted by means of suitable tubes to the funnel, thus preventing too rapid evaporation taking place.

It may also be arranged that a constant supply of water is dropped into the funnel, and the excess removed by attaching a piece of rubber tubing to the copper tube at the funnel and leading to the sink. This apparatus keeps a fairly constant temperature of about 210° Fah., and may be used for drying cotton cloth, etc.

AIR OVEN.—This is simply a box made of copper. It is heated by means of a Bunsen's flame, and the temperature may be regulated by the height of the flame used for heating it. It is suitable for drying substances where a higher temperature than the boiling point of water is desired. If used for drying substances like cotton cloth or yarns, care must be exercised, as these substances will scorch when the thermometer registers little more than 212° Fah.

FUNNELS.—These are of various capacities. The

sizes suitable for filtering ordinary precipitates are from one to two inches in diameter at the top.



FUNNEL STAND.—

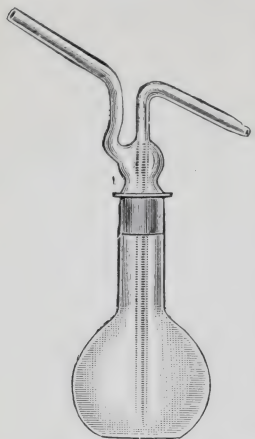
This stand is used as a support for the funnels, and may hold one or two as desired.

FILTER PAPER.—The operation of filtering a mixture is a very necessary and frequent one. For this purpose a kind of blotting paper is used.

Two qualities should be obtained; one for quantitative analysis, the percentage of ash of which is known, the other an ordinary white filter paper for qualitative work. They may be bought the exact size required, and should be folded so as to form a cone. This is placed in a suitable funnel and the mixture to be filtered poured over it. In quantitative analysis this operation requires very careful performance; the mixture should not be poured directly into the filter paper, but down a glass rod held to the lip of the vessel containing the mixture. By this means none of the mixture is lost by running down the outside of the vessel.

WASH BOTTLE.—This is used for the purpose of washing precipitates with either hot or

cold water. It consists of a glass flask fitted with a rubber or glass stopper having two holes. Two pieces of glass tubing are bent as shown in the illustration, and placed in position. Water is forced from the lower tube by blowing down the upper one. Where hot or boiling water is required the flask may be heated over a Bunsen's flame.



SPECIFIC GRAVITY BOTTLE.—This bottle is made to hold a certain fixed volume, and is used for the purpose of accurately determining the specific gravity of liquids; it is used as follows:—

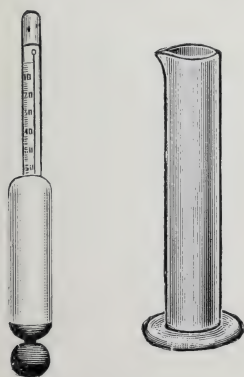


A dry specific gravity bottle, having a counterpoise, is rinsed out once or twice with the sample of the liquid to be tested, and allowed to drain for a few minutes. It is then filled up to the mouth with the sample to be weighed and the stopper inserted. The excess of liquid is forced out through the opening in the stopper of the bottle. The outside of the bottle is wiped perfectly dry, taking care not to hold it in direct contact with the hands, otherwise the temperature of the body will cause the liquid to expand and force it out of the hole in the stopper, so causing an error of observation.

The bottle and contents are placed on the

balance, with the counterpoise on the opposite pan. Weights are added until the balance is in equilibrium. The weight found is divided by the weight of water the bottle holds. Specific gravity bottles usually hold 25 grammes of water at 60° Fah., and are sold with a counterpoise.

The following calculation will show the student how to obtain the specific gravity. A bottle holding 25 grammes of water at 60° Fah. held 37·575 grammes of chloride of zinc solution at the same temperature. $37\cdot575 \div 25 = 1\cdot503$ specific gravity. From these figures, the degrees Twaddell may be obtained by dividing the figures after the decimal point by 5. Thus $503 \div 5 = 100\cdot6^\circ\text{T.}$ Conversely, the specific gravity may be found by multiplying the degrees Twaddell by 5 and adding 1,000, the specific gravity of water being taken as 1,000.



TEST GLASS—This glass is used for holding liquids, such as caustic soda, acids, etc., whilst ascertaining their specific gravity by means of the hydrometer.

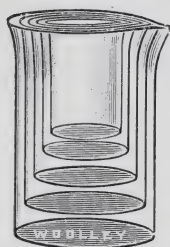
TWADDELL'S HYDROMETERS.—These instruments are used for showing the specific gravity of liquids heavier than water. In Twaddell's scale each degree is equal to (5 + 1,000) the specific gravity of water = 1,000. The hydro-

meters are numbered from 1 to 6, showing sp. g., as follows :—

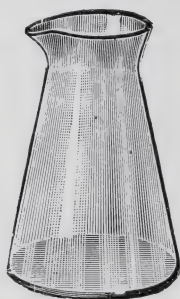
No. 1	...	0° to 24°	=	sp. g. 1000 to 1120
No. 2	...	24° to 48°	=	„ 1120 to 1240
No. 3	...	48° to 74°	=	„ 1240 to 1370
No. 4	...	74° to 102°	=	„ 1370 to 1510
No. 5	...	102° to 138°	=	„ 1510 to 1610
No. 6	...	138° to 170°	=	„ 1690 to 1850

These may be obtained either singly or in the set of six. In taking the Twaddell of a liquid, it should always be at a temperature of 60° Fah.

GLASS BEAKERS—Two kinds are required. No. 1 is made of thin Bohemian glass with a spout,



No. 1.

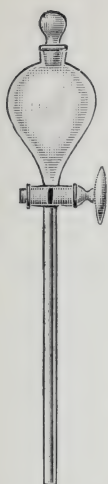


No. 2.

No. 2 is conical in shape; this latter is useful for digesting cloth in the quantitative determinations described under cloth analysis. These beakers stand hot

liquids, and may be heated by means of the Bunsen's flame if it be not applied direct. A piece of copper gauze should be placed on the tripod stand, or ring of the retort stand, and the Bunsen's burner placed underneath.

SEPARATING FUNNEL.—This instrument is used for separating such mixtures as the ethereal solution of fatty acids, or hydrocarbon oils, from the aqueous

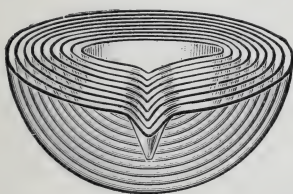


solution of soap, as described in the analysis of tallow. The most convenient size of separating funnel for general use is one having a capacity of 200 c.c. It should be pear shaped, fitted with a well-ground glass stopper, and a glass stop-cock for running off the lower layer from a mixture. The end of the stem should be filed off in an oblique manner to prevent any liquid remaining in it.

DESSICATOR.—This piece of apparatus is used for placing crucibles, and evaporating basins etc., in, whilst cooling. The air in the dessicator is kept free from moisture by means of strong sulphuric acid, or dried chloride of calcium, contained in a small beaker, placed at the bottom.



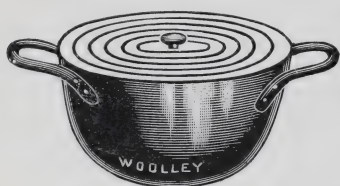
EVAPORATING BASINS.—It is necessary to have a number of assorted sizes of these useful articles.



The smaller sizes are used for evaporating small quantities of liquids, and the larger ones for many other purposes, details of which are given in the text. The evaporating basin recommended by the authors is that known as Royal Berlin porcelain. They are rather more expensive than the ordinary kind, but they stand heating much better. Basins of the following capacity will be found most useful, viz.:—

2 ounces, 4 ounces, 6 ounces, 8 ounces, and for boiling cloth, for the purpose of removing the size, one should be obtained having a capacity of 40 ounces.

WATER BATH.—This is used for evaporating liquids where the naked Bunsen's flame may not be used. It consists of a copper bowl or basin with a number of rings, fitting one within the other, adapted to take different sizes of evaporating basins. It is useful for evaporating such substances as ether,



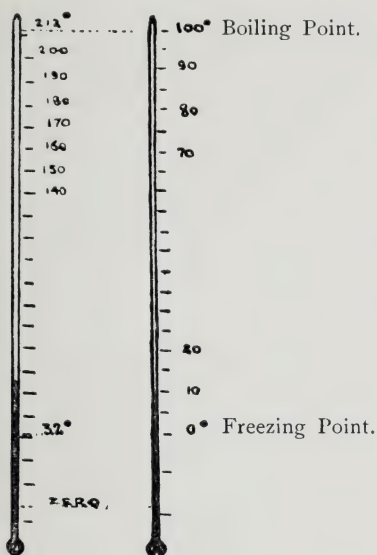
or alcohol, where a flame must not be applied directly to the basin. The method adopted, in these cases, is to heat the water in the bath to

boiling point; turn out the gas and place the evaporating basin containing the ether on the bath. With alcohol, the Bunsen's flame may be allowed to continue the heating, but with ether this should never be attempted, as this substance is so very inflammable, and is certain to take fire. The water bath should be used with the Soxhlet's apparatus to boil the ether in the flask when extracting fatty matter from cotton cloth, see chapter on cloth analysis.

THERMOMETERS.—There are two Thermometers in common use, the one by Fahrenheit, which is generally used by commercial men, and in everyday life; the other, the Centigrade, which is in almost general use amongst scientific men and in laboratories. The divisions in both are purely arbitrary,

excepting two points on each, viz.: those which indicate the freezing point and the boiling point of water.

In the Fahrenheit, the freezing point is taken at 32° , and the boiling point at 212° ; whilst in the



Fahrenheit.

Centigrade.

Centigrade, the freezing point is at 0° , and the boiling point, at 100° .

It is easily seen that the interval between the freezing point and the boiling point in the Fahrenheit scale is divided into 180 equal divisions or degrees, whilst in the Centigrade scale the same interval

is divided into 100 degrees.

CONVERSION OF THERMOMETRIC SCALES.

It is frequently necessary to convert degrees Fah. into degrees C. and conversely. For this purpose the following formulæ will be found useful:—

1. To convert degrees Fah. into degrees C.

$$\frac{(\text{Fah.} - 32) \times 5}{9} = \text{C.}$$

2. To convert degrees C. into degrees Fah.

$$\frac{\text{C.} \times 9}{5} + 32 = \text{Fah.}$$

EXAMPLES.

1. What temperature on the Centigrade scale is equal to 212° Fah.?

$$\begin{array}{r} 212 - 32 = 180 \\ 180 \times 5 \quad 900 \\ \hline 9 \quad 9 \quad = 100^\circ \end{array} \quad \text{Ans.} = 100^\circ \text{C.}$$

2. What temperature on the Centigrade scale is equal to 0° Fah.?

$$\begin{array}{r} 0 - 32 = - 32 \\ - 32 \times 5 \quad - 160 \\ \hline 9 \quad 9 \quad = - 17^\circ.77 \text{ C.} \end{array}$$

3. Express 60° C. on Fahrenheit's scale.

$$\begin{array}{r} 60 \times 9 \quad 540 \\ \hline 5 \quad 5 \quad 108 \end{array} \quad \text{Ans. } 108 + 32 = 140^\circ \text{ F.}$$

4. Express - 15° C. on Fahrenheit's scale.

$$\begin{array}{r} - 15 \times 9 \quad - 135 \\ \hline 5 \quad 5 \quad = - 27 \end{array} \quad \text{Ans. } - 27 + 32 = 5^\circ \text{ F.}$$



Crucible Tongs.



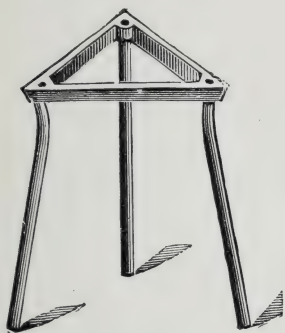
Crucible.



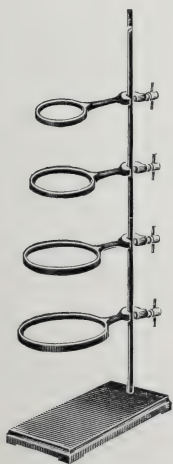
Triangle.

CRUCIBLE.—For most ignitions porcelain crucibles may be used, those known as Royal Berlin being the best. In certain work a platinum crucible is necessary.

TRIANGLES.—These are used for supporting the crucible, and are made from iron wire and pieces of pipe stem, or from iron wire, as shown in the illustration.



TRIPOD STAND.—This stand is usually about ten inches in height, and is used for supporting crucibles, beakers, etc. In the latter case, a piece of iron or copper gauze is placed on the stand so as to prevent the contact of the naked flame with the beaker.



RETORT STAND.—This stand with rings and clamps, etc., is used for holding retorts and condensers, or for supporting wire gauze or triangles on which beakers, evaporating basins, or crucibles are placed. The rings may be raised or lowered on the upright to the required height. The clamps, not shown in the illustration, are used to hold condensers, etc.

INDICATORS.

LITMUS PAPER.—Litmus paper is used for testing for the presence of free acid or free alkali. Blue litmus paper is turned red in the presence of all acids, and red litmus paper is turned blue in the presence of alkalies.

Litmus is useful for determining the presence or absence of acids, but it does not indicate the nature of the acid, *i.e.*, whether mineral or organic.

METHYL ORANGE.—A solution of methyl orange dye is a most useful indicator because it distinguishes between mineral acids and organic acids. In the presence of mineral acids and also oxalic acid it becomes pink, but it is not affected by most organic acids. The dye must be used in a very dilute form.

CONGO RED.—This dye is even more sensitive to mineral acids and oxalic acid than methyl orange. In a neutral or alkaline solution it is red, but in the presence of the above-mentioned acids it is turned blue.

The advantages of a reagent which can be used to differentiate between mineral acids, which are most injurious to cotton fibre, and organic acids, which are harmless, will be at once apparent, especially when it is necessary to determine the cause of damage. Litmus would be useless for such a purpose because it is acted upon by weak organic acids, and size almost invariably contains acids of this kind, due to decomposition of starchy matter, or to the presence of free fatty acids in the tallow.

CHAPTER I.

*Substances for giving Adhesive
Properties to Size.*

WHEATEN FLOUR, FARINA, MAIZE OR
CORN STARCH, SAGO, RICE FLOUR, RICE STARCH
TAPIOCA, SOLUBLE STARCH, DEXTRIN, GUMS, &c.

STARCH, in one form or another, is the most important substance used for giving adhesive properties to the size, and strength to the yarn. It is obtained for commercial purposes from various sources, but principally from the seeds of wheat, rice, and maize, the pith of plants (sago), and roots and tubers (tapioca and farina). Starch is found in cells in almost every part of plants. In its fully developed state it is most abundant in the matured structures, such as seeds, roots, pith, and other internal structures. Starch first makes its appearance as minute granules, in the interior of the chlorophyl grains, when exposed to sunlight. These granules are chemically acted upon, and dissolved, and the solution formed is passed

down from cell to cell until they reach certain portions of the plant structure, where they are reformed, and stored as a reservoir of food for future use in the plant's economy.

Pure starch is a white glistening powder. It is an amorphous non-volatile substance. When viewed under the microscope, each variety may be recognised by the characteristic size and shape of the granules (*see plate i.*). Starch is insoluble in cold water, alcohol, ether, or chloroform. It forms a mucilage with glycerine when heated with this substance and water. On boiling in water alone the granules swell to many times their original bulk apparently going into solution, but that this is not the case may be proved by passing the liquid through very fine filter paper. The filter paper retains the starch, allowing only the water to pass through. Intense cold will also precipitate the starch from the water.

TEST FOR STARCH.—Iodine has the property of colouring starch a beautiful indigo blue. This colour is destroyed on boiling. In testing for the presence of starch, the substance under examination should first be boiled with water, then allowed to cool, and a solution of iodine added. The colour is not produced in the presence of free alkali, and if this be present it must be neutralised with acetic acid. In the presence of free mineral acid, and oxalic acid, the boiling must not be too prolonged, otherwise the

starch will be converted into sugar and so remain undetected.

CHEMICAL COMPOSITION OF STARCH ($C_6H_{10}O_5$).—Starch is a compound consisting of carbon combined with the elements of water, hydrogen and oxygen. It never occurs in a pure state, but is always associated with a small quantity of mineral matter.

STRUCTURE OF STARCH GRANULES—Starch granules, when examined under the microscope with a sufficiently high power, are found to consist of a series of distinctly stratified concentric layers. The outer layers are denser than those near the hilum. This appearance is specially marked in farina starch.

The starch granule consists of the true starch compound and water ; the compound itself being composed of two substances, viz., granulose and cellulose. Granulose exists in the starch granule to the extent of about 95 per cent, and the cellulose, which is known as starch cellulose and is closely allied in its chemical properties to granulose, occurs to the extent of about 5 per cent.

Starch cellulose exists in a greater proportion in the outer layers of the starch granules. This portion is the oldest part of the granule, and in all probability cellulose forms the entire coating of the granule.

To the presence of this protective coating is to be attributed the fact that starch granules, when intact, are absolutely unacted upon by cold water. Although water is absorbed to a very great extent

by the granulose, none of this substance is able to diffuse into the surrounding medium. If, however, the outer layer of the granules be ruptured, water is rapidly absorbed, and the cell contents become swollen to a very great extent, and a small portion of the granulose is rendered soluble. By repeatedly treating the ruptured granules with water, the whole of the granulose may be removed, and the cellulose left behind in the form of extremely thin layers. This cellulose, when treated with iodine solution is coloured a dirty yellow, whilst starch granulose is coloured an intense indigo violet colour.

Granulose may be separated from starch cellulose by the action of saliva, diastase, and cold dilute mineral acids. Dilute sulphuric acid, two per cent strength, removes granulose after prolonged contact, but the readiest way to effect the separation is to treat starch paste with diastase or cold extract of malt. This reaction takes only a few minutes, and the cellulose may be separated by filtration. The residue, which is almost pure cellulose, should then be well washed with cold water. Starch cellulose obtained in this way is absolutely insoluble in cold water, and it is not acted upon by water heated to 180 degrees Fah., nor by a cold solution of diastase. Boiling water converts a portion of it into soluble starch, but even prolonged boiling does not render it entirely soluble. Starch cellulose is rendered entirely soluble by treating it with dilute

caustic soda or caustic potash. If the solution formed be treated with an excess of acetic acid, the cellulose may be precipitated. But if this solution be previously boiled, acetic acid will not precipitate it.

The question of starch cellulose is an important one from the sizer's point of view, as, in the authors' opinion, much of the difference in the properties of the various starches is due to the character and state of combination in which cellulose exists in the starch granule. There is a marked difference in the physical properties of size made from wheaten starch, maize, rice, farina, tapioca and sago. Maize and rice give a harsh stiff feel to the yarn, which no reasonable amount of boiling will remove. Wheaten starch, farina, and tapioca, on the other hand, give a softer and more mellow feel. The difference in the characteristics of these starches is generally attributed to the shape of the various granules, but, after boiling, the granules lose their shape entirely, and this cannot account for the difference in physical properties shown by the different starch pastes.

In experiments made by the authors it has been shown that when maize is partially converted into soluble starch by the action of hydrochloric acid gas, it resembles wheaten starch in its properties, and there is ample scope for further investigation into this matter.

The action of heat on the various starches also goes to prove the authors' contention that the outer

layer of cellulose of the starch granule is the determining factor in the nature of the paste produced by boiling the various starches in water. It has been found by experiment that these layers of the starch granule, which are rich in granulose, are readily converted into soluble starch and dextrin on heating, whilst those rich in cellulose undergo this transformation only after prolonged treatment. It has also been proved by experiment that rice starch, and to a less degree maize starch, shows the greatest resistance to heat, whereas such starches as farina, tapioca, wheat and sago, are much more readily transformed into soluble starch and dextrin.

ACTION OF HOT WATER ON STARCH.—It has been previously stated that starch is gelatinised by hot water. The temperature at which this is brought about differs with the various starches. The following table shows the temperature at which complete gelatinisation occurs :—

Classes of Starch.	Temperature at which complete gelatinisation takes place.
Wheaten Starch.....	176° Fah.
Rice Starch	179° Fah.
Maize	167° Fah.
Farina.....	149° Fah

Under the action of boiling water, the starch granules do not all burst at once. The younger

granules are the first to be acted upon, and, as the contact with the boiling water is continued the whole of the granules undergo gelatinisation.

ACTION OF CAUSTIC SODA AND POTASH ON STARCH.—These caustic alkalies have a peculiar action on starch. If starch be boiled with water containing only one-half per cent. of caustic soda, a paste is formed which is much thicker, and very much more adhesive, than if boiled with water alone. A higher percentage of the alkali produces a still greater adhesiveness. These substances also tend to prevent the decomposition of the starch paste, especially farina paste; the acids, which are formed by this decomposition, are immediately neutralised by the alkali. This has the effect of preventing the development of mildew to a great extent. Why caustic soda prevents the decomposition of farina paste is not known. Whether it be due to the actual combination of the alkali with the starch compound, or whether it be due to the alkali retarding the formation of organic acids produced by bacterial action, or whether by its presence in the caustic state, it prevents bacterial action, the authors are not prepared to say, but they believe that the whole of these conditions play a part in it.

If starch be treated with a cold concentrated solution of caustic soda, it swells out, forming a paste of great tenacity, resembling in appearance a mass of gluten, such as may be obtained from good

wheaten flour. The starch, so treated, does not lose much of its increased adhesiveness on boiling, even when the alkali is previously neutralised with acids. Whilst cold the neutralised starch is converted into a thin liquid, but on boiling, it is found to be nearly as tenacious as it was before.

Advantage has been taken of this action of caustic soda and potash on starch to place upon the market many substances for sizing purposes. These are generally starch boiled with water and caustic soda, or starch treated with concentrated caustic soda in the cold. In some cases they take the form of a highly glutenous-looking mass, consisting of starch and caustic soda. In other cases, two liquids are sold, one being a solution of caustic soda, and the other a mineral acid, generally sulphuric. These are made of such a strength as to nearly neutralise each other; the caustic soda, which must be in slight excess, Twaddelling about 70° , and the sulphuric acid Twaddelling about 44° . The former containing approximately 28 per cent. of NaHO , and the latter 30 per cent. H_2SO_4 .

Another preparation consists of soap and water, to which an excess of caustic soda has been added. The value of this product for sizing purposes is represented by the amount of free caustic soda present in it.

These various preparations are not new, one of the older being known as *apparatine*. This substance will be further discussed later in this chapter.

ACTION OF ACIDS ON STARCH.—When starch and water are boiled with weak mineral acids, the starch is converted first into dextrin, and finally into glucose. If strong sulphuric acid be used, carbonisation quickly takes place, whilst strong nitric acid, under similar conditions, converts the starch into oxalic acid. In the cold, however, *strong* sulphuric hydrochloric, and nitric acid, causes the starch simply to swell out, forming a paste.

Tannic acid combines with starch, precipitating it from solutions. In sufficient quantity, this acid entirely prevents the conversion of starch into dextrin and maltose by means of diastase. (see page 47).

The organic acids, produced by the fermentation of starch paste, seem to have the power of converting the starch into sugar when boiled. This is especially so in the case of farina.

ACTION OF CALCIUM, MAGNESIUM, AND ZINC SALTS ON STARCH.—Starch has the property of combining with many other bases besides caustic soda and caustic potash. If a dilute solution of calcium chloride be added to the solution formed by boiling starch with caustic soda and water, a double decomposition takes place, and a white insoluble mass is formed, which is a compound of calcium and starch. The starch in this compound cannot be detected by iodine, but the addition of an acid liberates the starch, which may then be detected by iodine in the usual way.

Although a dilute solution of chloride of calcium precipitates starch as an insoluble compound, it is remarkable that if starch be boiled for three or four hours with a saturated solution of this substance, it is rendered soluble, and when the solution cools, it sets up into a stiff gummy mass.

A strong solution of chloride of zinc, or a strong solution of chloride of magnesium, when boiled with starch, produces a somewhat similar result to that produced by chloride of calcium. The products obtained by this treatment are much more adhesive than starch boiled with water, and this has been turned to account by many manufacturers of sizing specialities. This matter is further dealt with under soluble starch.

Starch is precipitated from solution by means of a solution of lime (hydrate of calcium) in sugar syrup. Solutions of hydrate of barium, and hydrate of strontium combine with starch also, producing insoluble compounds, in which the starch is not detected by means of iodine solution, unless the compounds are first decomposed by means of an acid.

Magnesium salts, in dilute solution, precipitate starch from solution in the same way as calcium salts.

ACTION OF BORAX ON STARCH PASTE.—When a mixture of starch and water is heated to a temperature sufficiently high to gelatinise the starch granules, it forms a viscid mass. In this state it will adhere to almost any substance with which it may come in

contact, and it may be spread by means of a brush or by means of a spatula. But if a small quantity of borax be added to the starch paste, and the mixture kept constantly stirred by means of a glass rod for a short time, a most peculiar effect is produced on the ruptured starch granules. The mass first begins to thicken, and the paste becomes less viscid, until it finally loses its power of adhering to other substances, and instead, it is found to possess most marked powers of self-adhesiveness. The mass has now the appearance of a watery jelly, and it may be rolled in the hands without any of it adhering to them. The borax seems to cause a coagulation similar in effect to that produced when an egg is boiled. Before boiling, the white of the egg is thin and viscid, whilst after boiling it is thick, and the viscosity has disappeared.

This result may be obtained from any of the starches, when treated as described above, but it is most marked in the case of farina. An experiment illustrating this peculiar change may be made as follows :—

Mix one ounce of farina with six ounces of water in an evaporating basin, and heat the mixture by means of the Bunsen's flame, or better by means of steam, until the granules burst. The source of heat is then removed and a few drops of solution of borax added. The mixture is kept well stirred, and in a few minutes it will be seen that it is losing its

viscosity, and, instead of adhering to the sides of the basin, it clings together in a tenacious jelly-like mass, which can be lifted bodily from the basin. This mass may be rolled between the hands without adhering to them, and what is more remarkable, without showing any apparent "wetness." If the jelly-like mass be placed on blotting paper, the paper does not become damp. It has, in fact, lost all the physical characteristics of starch paste. If a ball of this jelly-like mass be left for a few days, it either dries up into a hard crystalline looking mass, or else the water separates out from it bodily, leaving the starch behind.

This action of borax on starch paste is peculiar and interesting. It was discovered by the authors whilst experimenting with a view to finding out the action of different substances on the various starches. Whether it can ever be turned to practical use for sizing, or for any other purpose, is a matter which requires further investigation. Borax has been used for many years in conjunction with starch for giving a gloss to linen, and, as a matter of fact, borax is the basis of most of the so-called starch glosses. Whether the glossing effect is due to the hot iron, which is used in the glossing process, breaking up, or gelatinising the starch, and thus making it susceptible to the action of the borax, in the same manner in which starch paste is acted upon by borax, the authors are not prepared to say, but

they think that this is probably the action which takes place.

ACTION OF DIASTASE ON STARCH.—Diastase, the active principle of malted grain, has the power of decomposing starch, in the presence of water, at a temperature of 140° to 160° Fah., forming dextrin and maltose.



This action of diastase is turned to practical use by the bleacher and finisher when it is necessary to remove the starch from goods which have been wrongly finished, and where it is not desirable to send them through the bleaching process again. For this purpose diastase, in the form of ground malt, is used. The cloth is steeped for a few hours in a solution of malt, at a temperature of 140° Fah., and in that time, the insoluble starch is converted into soluble dextrin and maltose, which may be readily washed out by boiling in water. The action of diastase on starch is further discussed under soluble starch.

ACTION OF BACTERIA ON STARCH.—Starch pastes, produced by boiling starch with water, are more or less liable to decomposition by the action of bacteria. Some starches show a much greater tendency to decompose from this cause than others. Farina and tapioca are particularly liable to this process of decomposition and it is certainly curious that this

action should be most pronounced in starches obtained from roots and tubers, and which of necessity, have been developed underground. It is highly probable that close contact with the soil, highly charged with nitrogenous matter, may be the cause of this tendency to decomposition. Starches obtained from seeds, and from the pith of plants, are not so subject to decomposition.

The products of decomposition, brought about by bacterial action, are chiefly dextrin, glucose, carbon dioxide, ethyl and amyl alcohols, and acetic and butyric acids. Villiers found that the addition of a pure cultivation of *Bacillus amylobacter* to a 5 per cent. starch paste causes complete liquefaction in 24 hours, and on allowing the fermentation to continue some time, the liquid no longer gave a blue colouration with iodine. The products of the change in this case were entirely dextrins, neither maltose nor dextrose being found to be present. This shows that this particular organism converts starch directly into dextrin without the intervention of any diastase secreted by the ferment. This matter is further discussed under farina.

IDENTIFICATION OF THE VARIOUS STARCHES.

The various starches can be identified only by means of the microscope, and this most valuable instrument should be in the hands of every manufacturer.

The starches are prepared for examination as follows :—A small quantity of the sample is thoroughly rubbed up with water in a watch glass, by means of a glass rod. A drop of the milky fluid is then placed on the centre of a glass slide, and a thin cover glass placed over it. Any excess of liquid is removed from the edges of the cover by means of blotting paper. The slide is then placed on the stage of the microscope, the body of which is brought down carefully by means of the large adjusting screw, until the granules of starch are visible, the exact focus being obtained by careful adjustment with the fine screw. The granules of the various starches differ considerably in size and shape, and very little practice is necessary to enable the operator to readily distinguish all those which come under the notice of the sizer, whether examined separately or in mixtures.

An illustration, showing the microscopical appearance of the most important starch granules, is given on *plate i.* The following description enumerates their characteristic features :—

WHEATEN STARCH.—The granules of wheaten starch vary considerably in size. The smaller ones are generally round, and they are provided with a dark central spot or hilum, which, however, requires a power of 460 diameters to distinguish. The large granules are more or less rounded, and marked with concentric rings. The small wheaten starch granules

might be mistaken for rice starch by the novice, but they are seen to be very different if carefully examined; those of wheaten starch being round, whilst rice starch granules are angular.

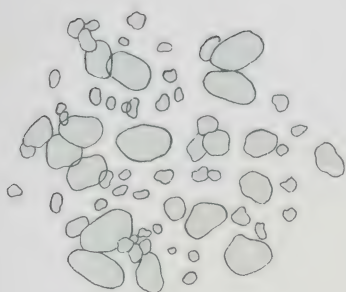
A comparison should be made by making up three slides, and examining one after the other. The first should be pure wheaten starch, the second pure rice starch, and the third a mixture of the two.

MAIZE OR CORN STARCH.—This starch is readily identified under the microscope. The granules are very even in size, and they present the appearance of having been originally rounded, but by contact, and probably by pressure, the edges have become flattened, thus giving them a polyhedral form. The majority of the granules have a star-shaped appearance in the centre when viewed under the microscope. Sometimes this takes more the form of a Y.

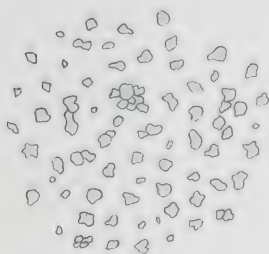
Maize starch granules are smaller than the larger wheaten starch granules.

FARINA OR POTATO STARCH.—The granules of this starch are larger than those of any other starch used for sizing. They are oval in shape and are marked, in many cases, but not always, with concentric rings. The appearance of this starch under the microscope is an important indication of its quality. In good samples of farina the granules are of an even size, whilst in inferior samples the granules are very irregular in size, and very often the larger

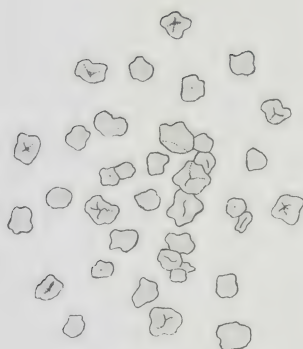
THE STARCHES.



WHEAT



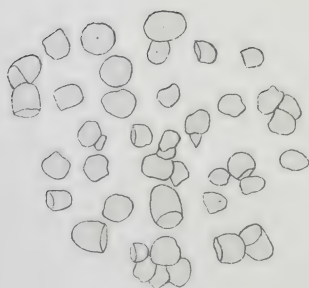
RICE



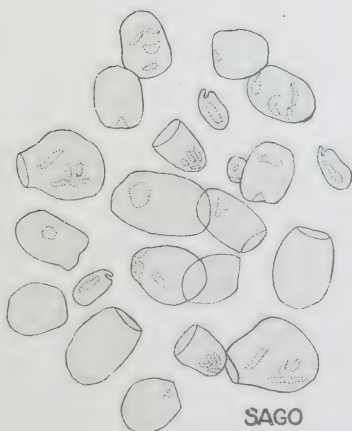
MAIZE



FARINA



TAPIOCA



SAGO

MICROSCOPIC APPEARANCE OF STARCH GRANULES.

Plate I.

granules are more or less frayed at the edges. This matter is further dealt with in the section devoted to farina.

SAGO STARCH.—The chief characteristic of the granules of this starch is the flattened end of each granule. The granules are smaller than farina granules, and they are more irregular in shape. Many are ovate, whilst others are more rounded and show irregular protuberances, not unlike those seen in certain potatoes. The surface of the sago granules, as seen under the microscope, is characterised by a number of peculiar markings.

RICE STARCH.—The granules of this starch are amongst the smallest known, their polyhedral shape rendering them easy of detection. When rice flour, or ground rice, is under examination, it is necessary to grind it in water for some little time, in order to bring about a separation of the starch from the gluten.

TAPIOCA STARCH.—The granules of this starch vary more in appearance than those of any of the other starches used in sizing. This is probably due to the fact that the tapioca of commerce is obtained from a variety of plants. Tapioca granules are about the same size as maize granules, but they are altogether different in appearance. In some cases the granules are perfectly round and show a central dot or hilum, whilst in other cases the granules are D shaped. In any case tapioca is readily distinguished from those starches already described.

WHEATEN FLOUR.

Wheaten flour is the most important of all the substances used for giving adhesive property to size. It is a complex substance containing a number of organic bodies, the most important of which are starch, gluten, albumen, sugar, dextrin, and cellulose. There is also present a small quantity of mineral matter.

The value of a sample of wheaten flour for sizing purposes depends upon the proportion and the quality of the starch and gluten contained therein. It is therefore necessary that care should be exercised in its selection.

Before describing the tests which should be applied to wheaten flour it will be advisable to describe the various substances found present in it.

CELLULOSE.—This substance resembles the fibre of wood. An example of cellulose, but a modification of the kind found in flour, is ordinary cotton.

GLUTEN.—Gluten is a powerfully adhesive substance found in wheaten and other flours. It may be readily separated from wheaten flour by kneading a portion of flour with a little water. The dough produced is placed in a bag of silk, or fine linen, and gently pressed in contact with a stream of running water. By this treatment the whole of the starch, and the soluble matters of the flour, are washed away, and there remains behind a sticky mass which is very rich in nitrogen. This crude gluten

consists chiefly of gluten-fibrin, gluten, and mucedin, with small quantities of fat and mineral matter.

ALBUMEN.—This nitrogenous substance is indetical with the albumen found in animals. The white of an egg may be taken as representing almost pure albumen. The albumen of flour is soluble in cold water, and it is coagulated, and precipitated, when the solution is boiled.

DEXTRIN.—This substance is always found in flour. It is soluble in cold water, and may be separated from the other constituents of flour by digesting a small quantity of flour with water. The liquid is filtered off, boiled to coagulate the albumen, and again filtered. The solution thus obtained will contain the dextrin and the sugar present in the flour. The presence of dextrin is ascertained by its reaction with iodine solution. Iodine imparts a reddish purple colour to the solution containing dextrin.

SUGAR.—This substance is a natural constituent of flour. It occurs in the form known as glucose or grape sugar, a form which differs somewhat in chemical and physical properties from ordinary cane or crystallisable sugar.

STARCH.—This most essential constituent of wheaten flour has been fully dealt with already.

MINERAL MATTER.—This is found in all flours. It is left as ash when the flour is burned, and it is composed principally of potash and phosphoric acid, with smaller proportions of soda, lime, magnesia and

iron oxide, in combination with sulphuric, carbonic, and silicic acids, and chlorine.

BRAN.—This is the cortical part of the grain. It is sometimes found in flour through imperfect dressing.

WATER.—This is an essential constituent of all vegetables. The average amount found in wheaten flour is about 13 per cent.

It would be a great advantage to the sizer if he knew the composition of each consignment of flour he used in his mixings, as it would ensure greater uniformity in his results, but the time occupied in making a full analysis puts it beyond his reach in most cases. It is possible, however, to apply many simple tests, particulars of which are given herewith, to determine the quality of a flour for sizing purposes, and these tests, if carefully carried out and the results recorded, would prove of great utility, and lead to greater uniformity in the results obtained in sizing.

DETERMINATION OF THE VALUE OF WHEATEN FLOUR FOR SIZING PURPOSES.

COLOUR.—Flour should not be dark in colour. The whiter the flour the less chance it has of affecting the colour of the woven cloth. The test for colour should be made by comparison with a “standard” flour. A good sample as regards colour

should be kept for this purpose. The test is made by placing a little of the sample under examination by the side of the "standard" sample on a sheet of blue paper. On pressing them flat with a knife any difference in shade is readily seen at the point of contact.

A further test should always be made by boiling the same quantities of the samples with water, the proportions being the same as given in the test for consistency. Some samples of flour alter in colour to an appreciable extent when boiled.

CONSISTENCY OF FLOUR PASTE.—The value of a pure wheaten flour for sizing purposes may be judged by the "stiffness" of the paste produced by boiling a definite weight of flour with a definite measure of water, and comparing it with the "standard" treated in the same way. For this purpose the authors use 10 grammes of flour and 100 cubic centimetres of water, or 1 ounce of flour to 10 ounces of water.

The samples of flour are placed in small cylindrical beakers, and the water is added from a 100 c.c. pipette, or it is carefully measured in a suitable glass measure. The mixture is carefully stirred with a glass rod in order to thoroughly break up the particles of flour, thus getting an even mixture free from lumps. The beakers are then placed in a vessel containing water, which is heated by means of a Bunsen's flame, the contents being kept constantly stirred during the whole process.

The most suitable vessel for heating the flour is an iron pan to which is fitted a brass or copper disc in which four or five circular holes, sufficiently large to pass the beakers through, have been cut. The beakers are supported on the disc by their rims. The disc should be mounted on supports so as to prevent the bottoms of the beakers touching the bottom of the pan. By using an apparatus such as described above an accurate comparison of several samples may be made at the same time, as the samples are heated under identical conditions. It is advisable to heat the samples for 15 minutes, and the water in the pan should be boiling before they are placed in it. If more than two samples are being examined it will, of course, be necessary to have assistance in the stirring until the granules of starch burst, afterwards they may be stirred alternately. The advantages of the above method are that the same amount of evaporation of the water mixed with the flour or starch takes place, and there is not the same liability of error as there would be if separate samples were boiled for a definite time.

After the contents of the beakers have been heated for the specified time they are removed from the pan and allowed to cool for twelve hours. They may then be examined for consistency and colour. Any variation in consistency may be readily judged by pressing the fingers into each sample of paste.

N.B.—It is important to remember that the foregoing tests are of value only when comparing *pure* samples of wheaten flours. The tests become worthless if any of the samples under examination are mixtures containing maize starch. This starch is much whiter than wheaten flour, and it gives a thicker paste. It will, therefore, be readily seen how the sizer may be misled in his estimation of the value of a flour unless he has previously determined its purity. It would be quite possible for him to select a poor flour mixed with maize starch if he depended upon the colour, and the consistency of the paste obtained by boiling the sample with water. But if he bases his opinion on the whole of the tests given for flour, especially as regards the *quality* of the gluten, he cannot get far wrong. The authors would strongly urge upon manufacturers the desirability of having nothing to do with wheaten flours mixed with other starches. If it be necessary to improve the colour it will be far better if he mixes the requisite amount of maize starch with it himself.

Another point to remember is that, within recent years, it has become a fairly common practice to subject dark coloured low grade flours to a bleaching operation. It does not therefore follow that whiteness is an indication of high quality.

ESTIMATION OF MOISTURE.—It is very necessary that the amount of moisture present in a sample

of flour should be estimated. The method of procedure is described on pages 22 and 23.

ESTIMATION OF GLUTEN.—In order to determine the proportion of gluten in a sample of flour, exactly 10 grammes should be weighed, and transferred to a porcelain mortar. A sufficient quantity of water is then added and the mixture is kneaded into a dough by the aid of the pestle. Care must be taken not to use more water than is necessary to produce a dough which should leave the mortar without leaving a trace behind. The dough should be allowed to stand, in every case, for half-an-hour. It is then transferred to a fine linen or silk cloth, which has been previously wetted with water, and tied up in such a way as to form a bag. This is gently pressed with the fingers in a stream of running water, in order to wash away the starch.

A portion of the milky fluid should be collected in a suitable vessel for the microscopical examination previously described on page 49.

The washing must be continued until the water begins to run away clear. The bag is then opened and the gluten examined. Gluten from a good sound flour is found self-adherent, in an elastic mass, whilst gluten from an unsound or weak flour will be found in the form of little pellets, having no tendency to adhere in a single mass. Occasionally, where the gluten is very weak, it will pass through the cloth, and will be found adhering to the outside.

The gluten should be removed from the cloth, and thoroughly washed in a stream of running water, by holding it in the ball of one hand, and kneading it with the fingers of the other hand, until the washings show no sign of starch. This point is readily determined by squeezing the water from the wet gluten into a beaker full of clear water. If all the starch has been removed, the water in the beaker will remain clear, whereas it will be rendered turbid if starch be present. In the latter case the washing must be continued.

Sometimes the gluten will be found to be covered with granular particles. This may be due to the flour having been adulterated with rice or maize *flour*, or it may be due to some portion of the flour not having been properly ground. These gritty granular particles should be washed from the gluten into a suitable vessel, and examined separately under the microscope.

The gluten may be weighed either as moist or dry gluten. If weighed as moist gluten the mass should be rolled between the dry palms of the hands until it begins to stick slightly to them. The moisture is evaporated by the warmth of the hands. The gluten is then quickly placed upon a tared watch glass and the whole weighed. The weight of the watch glass, deducted from the total weight, gives the amount of moist gluten, and this multiplied by 10 gives the percentage of moist gluten present in the sample.

It is preferable to determine the amount of the gluten both in the moist and the dried state, and when this is done it is advisable to perform the weighings on a small thin sheet of tinned iron kept for the purpose, instead of on a watch glass. This is because the gluten is so powerfully adhesive that it will pull pieces out of the glass as it contracts on drying.

In determining the amount of both moist and dry gluten, the moist gluten is first weighed. The plate containing it is then placed in the steam or air oven, until the weight, after cooling in the desiccator, remains constant. This weight, multiplied by 10, gives the percentage of dry gluten.

The percentage of dry gluten may be calculated from the percentage of moist gluten by dividing the latter by 2.61. This calculation may be used as a check on the accuracy of the estimation where both moist and dry gluten is determined.

Gluten, when of good quality, is a powerfully adhesive substance, and flour containing a moderately high percentage of it is useful in fixing China clay on the yarn.

Wheaten flours vary very considerably in the amount and quality of gluten contained in them, and, as a rule, the value of a flour for sizing purposes is based on these points. There is no doubt that the quantity, and more especially the quality, of gluten are most important factors in determining the value of a sizing flour, as it invariably follows that

where the gluten is high in quality the starch present in the sample is well matured and strong.

The amount of *moist* gluten found by the authors in the examination of many samples of sizing flours varies from 5·14 per cent. in very poor samples, to 39 per cent. in very good ones. The latter figure represents nearly 15 per cent. of *dry* gluten and the former nearly 2 per cent.

Sizers differ very greatly in their opinion as to the value of gluten for sizing purposes. Many contend that a flour containing a high percentage of gluten is the best, whilst others maintain that a flour containing a medium percentage of this substance is the more valuable. If it were a question of food, then there can be no doubt that a high percentage of gluten in a flour would be advantageous, but for sizing purposes it is not so necessary that the gluten should be present in very large quantities so much as that it should be sound and strong. The authors recommend a flour containing from 9 to 12 per cent. of dry gluten, providing the gluten is of high quality. As a matter of fact a great deal depends also upon the treatment to which the flour is to be subjected previous to its being made into size. This matter will be discussed when dealing with the fermentation of flour.

MINERAL MATTER OR ASH.—Flour free from adulteration contains from 0·7% to 0·8% of ash. Anything above 1% should be looked upon with

suspicion. In determining the question of mineral adulteration it is only necessary for the sizer to know that his flour does not contain an excess of mineral matter. To obtain this information a known weight of flour should be burnt in a platinum or porcelain crucible, the resultant ash carefully weighed, and calculated to a percentage. The method of procedure is as follows:—A crucible with a lid is heated in the Bunsen's flame, and then allowed to cool in the desiccator. When cold it is carefully weighed on the balance, and the weight noted. About two grammes of flour should be placed in the crucible and the whole weighed again. The difference in the first and second weighings gives the amount of flour taken. The crucible, with its contents, is placed on a triangle, supported on a tripod stand. Heat is applied by means of a Bunsen's flame. The flour is quickly converted into a hard mass of charcoal, which, on continuing the heating for an hour or two, is burnt away, leaving a white or grey ash. At this point the lid of the crucible is put on, the whole allowed to cool in the desiccator, and then weighed. The weight of the lid and crucible deducted from the total weight, gives the amount of ash, and this should be calculated to a percentage in the usual way.

Another way of roughly estimating the amount of mineral matter present in a sample of flour or starch, is to make a comparative test as follows:—

A small thimble-full of flour of known purity is placed in a long narrow test tube. The tube is half filled with chloroform and well shaken. The same quantity of the sample to be tested is placed in a similar tube, with the same quantity of chloroform and well shaken. The two samples are allowed to stand for about six hours, after which they are compared. Pure flour or starch will float on the surface of the chloroform, this liquid being much heavier than flour, whilst mineral matters, such as China clay or plaster of Paris, will sink to the bottom of the test tube. A comparison of the two test tubes will show whether there is any adulteration of the sample under examination.

ADULTERATION WITH OTHER STARCHES.—Wheaten flour is frequently mixed with other starches. Sometimes this is done simply for the sake of extra profit and sometimes it is done by dealers who make a special sizing flour. In any case it is important that the sizer should know the constituents of the flour he is using, otherwise he becomes dependent upon one dealer for his flour, or else he may get results he is not expecting if he changes his source of supply.

The various starches used for admixture with flour may be detected by means of the microscope in the manner already described. The starches most likely to be found as adulterants in wheaten flour are rice and maize flours, maize starch, and tapioca. The market price of the starches of course governs

the particular one which is used for the purpose of adulteration at the moment.

The microscopic appearance of wheaten starch is a very valuable indication of its value for sizing purposes. It will be invariably found that a flour composed of well developed granules is a stronger flour than one in which there are a very large number of the smaller granules. This is a point never mentioned in books dealing with flour for sizing purposes, but it is one which experience has shown to be of the greatest importance.

ANALYSIS OF WHEATEN FLOUR.

A full analysis of flour is too long and tedious an operation as a rule for a manufacturer to attempt, but it is necessary to detail the process for the guidance of those students who wish to go fully into the matter.

The following will be found to be a useful method of procedure:—

(1) **MOISTURE.**—This is determined by drying three or four grammes in the water oven until the sample ceases to lose weight, as described on pages 22 and 23. The water is calculated to a percentage.

(2) **ASH.**—This is determined by carefully burning from one to two grammes of flour in a platinum crucible, as described on pages 61 and 62, and, after weighing the residue, calculating to a percentage of the flour taken.

(3) GLUTEN.—This is determined by washing, as described on page 57, *et seq.*, and weighing as dry gluten. The amount found is calculated to a percentage of the flour taken.

(4) SOLUBLE ALBUMINOIDS, GLUCOSE AND DEXTRIN.—The following method may be used for estimating the soluble albuminoids, etc., in flour.—10 grammes of flour are treated with 40 cubic centimeters of cold water. The mixture is allowed to stand for exactly one hour. The liquid is then passed through a dry filter, and after allowing the first portions to run away, the rest of the liquid is collected and examined as follows:—20 cubic centimeters of the filtrate (= 5 grammes of flour) should then be collected and treated with an equal volume of methylated spirit. By this treatment the soluble albuminoids are precipitated, the amount of which will depend upon the quality of the flour, the best samples giving the least quantity of precipitate. The albumen is filtered out and the liquid is collected in a weighed evaporating basin. The precipitate is carefully washed with water, and the washings are added to the contents of the basin. The filtrate and washings are then evaporated to dryness on the water bath, afterwards heated in the drying oven, and then weighed. The weight obtained deducted from the weight of the basin, gives the total weight of sugar and dextrin in 5 grammes of flour, and this multiplied by 20 gives the percentage.

SOLUBLE ALBUMINOIDS.—The amount of soluble albuminoids should be determined as follows:—10 cubic centimeters of the original filtrate should be evaporated to dryness, as previously described, in a tared evaporating basin. The weight obtained gives the total soluble albuminoids, sugar, etc., in $2\frac{1}{2}$ grammes of flour. This multiplied by 40 gives the percentage. From this total percentage deduct the percentage of sugar and dextrin found, the balance is the percentage of soluble albuminoids.

(5) STARCH.—After determining the percentage of moisture, ash, dry gluten, soluble albuminoids, etc., the amount of starch in flour may be calculated roughly by difference. Where a direct determination is required, the following process, described in Allen's commercial organic analysis, will be found useful.

Any fat or oil should first be removed by treatment with ether. The flour is then treated with a saturated solution of salicylic acid in cold water. This will dissolve alkaline salts, sugar, dextrin, etc. The liquid is filtered and the residue washed with decinormal caustic soda to remove salicylic acid and albuminoids. The residue is rinsed off the filter with warm water and heated to boiling point, in order to gelatinise the starch. The mixtures must be kept constantly stirred. The product is then treated with a known measure of recently prepared, and filtered cold infusion of malt, of which the specific gravity has been previously ascertained. The mixture is

kept at a temperature of about 140° to 145 Fah., with occasional stirring, until a drop, taken out with a glass rod and added to a drop of iodine solution on a porcelain plate, shows no blue or brown colouration. The solution is then filtered, made up to a definite volume, and its specific gravity accurately ascertained. From the excess of the density over water is subtracted the density due to the infusion of malt used, allowance being made for the increased volume of the liquid, when the difference represents the density due to the starch dissolved, and this number divided by 4.096 ($= 3.395 + 1.037$) gives the number of grammes of starch in each 100 c.c. of the solution.

Thus, suppose 10 grammes of the sample be taken, and, after treatment with ether and salicylic acid, and soda solutions, in the manner described, the residue is treated with 50 c.c. of water and 5 c.c. of infusion of malt of 1.060 sp. gravity; the liquid being subsequently made up to 100 c.c. and found to have a density of 1.033. Then, the correction due to the malt infusion will be

$$\frac{(1.060 - 1.000) \times 5}{100} = 3.,$$

this subtracted from the difference between the density of the solution and that of water ($1.033 - 1.000$) = 33 leaves 30 as the excess density caused by the solution of the starch of the sample; and this figure, divided by 4.096, gives 7.324 grammes per 100 c.c., or in the 10 grammes taken; or 73.24 per cent. of starch in the sample.

The following simple method of estimating the amount of starch in flour is described by J. Muter. The author has found it very serviceable. "It depends upon the fact that starch forms an insoluble compound with barium. If an excess of baryta water of known strength be added to starch which has been previously gelatinised in water, a portion of the barium will combine with the starch, and then by estimating the amount of baryta water left uncombined, the amount taken up by the starch may be ascertained. The formula of the starch-baryta compound is $C_{24}H_{49}O_{20}BaO$, and it therefore contains 19.1 per cent of BaO .

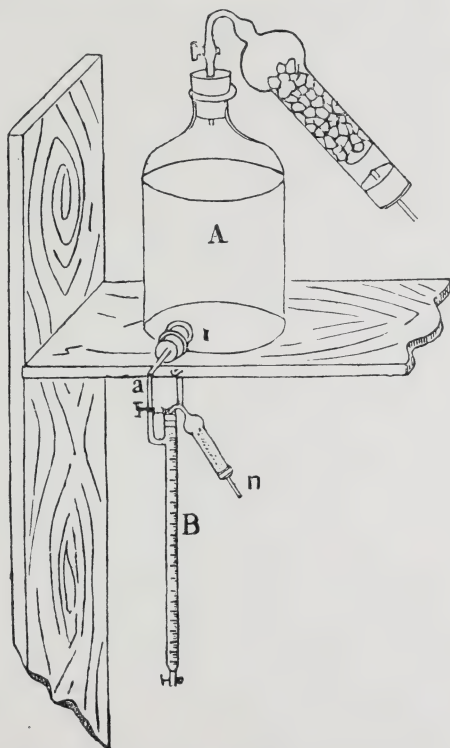
The Materials required are :—

(1) Decinormal hydrochloric acid, containing 3.65 grammes of real HCl per 1,000 c.c. = .00765 BaO for each c.c.

(2) Baryta water kept in a special jar with a burette permanently attached as shown in the illustration. (A) is the jar for the baryta water, having a tube attached containing lumps of quicklime to prevent the entrance of CO_2 from the atmosphere when any liquid is run off. The burette (B) is attached to the bottom neck of the jar by a tube having a pinchcock (a) to admit the reagent, and a tube (n) filled with lumps of caustic potash to prevent entrance of CO_2 .

(3) Alcoholic solution of phenol-phthalein as the indicator.

THE PROCESS.—3 grammes of flour are first treated with ether or petroleum spirit in the “Soxhlet” (see chapter on cloth analysis) to remove any fat. The powder is then well rubbed in with successive quantities of water until thoroughly disintegrated, the liquid being transferred to a 250 c.c. flask, 100 c.c.



Apparatus for the estimation of Starch.

of water in all being used to entirely transfer the powder from the mortar to the flask. The flask and contents are now heated on the water bath for half-an-hour, with frequent shaking, to *entirely gelatinise* the starch. The whole is then cooled, and 50 c.c. of

standard baryta water having been added from the burette, the flask is corked, well shaken for two minutes, proof spirit is added up to the 250 c.c. mark, and the whole again shaken, *tightly corked*, and set aside to settle. While settling, a check is made on 10 c.c. of the baryta water by shaking up with 100 c.c. of freshly boiled distilled water, in a 250 c.c. corked flask, and then titrating with decinormal HCl, in the presence of two drops of phenol-phthalein solution. The number of c.c. of acid used is recorded, giving the total strength of 50 c.c. of the baryta water employed. When the main analysis has settled, 50 c.c. of the clear liquid are drawn off with a pipette, rapidly titrated with the decinormal acid and phenol-phthalein, as in the check, and the number of c.c. of acid used is multiplied by 5 and set down as the strength of baryta water remaining uncombined. This latter amount is deducted from the total check strength, and the difference in c.c. of acid is multiplied by '00765, which gives BaO combined with the starch. This result multiplied by 4'2353 gives the amount of starch in the 3 grammes taken = x : then

$$\frac{x \times 100}{3} = \text{percentage of starch.}$$

The determination of the amount of starch in a sample of flour may also be made in the following way :—A weighed quantity of flour is kneaded into a dough and then placed on a fine sieve over a suitable

vessel for collecting the starch. A stream of water is allowed to trickle over it, kneading well all the time. When the water runs away clear it is allowed to stand, and when the starch has all settled out, the water is poured off and the deposited starch collected, dried at $110^{\circ}\text{C}.$, and weighed. This method is convenient but rough."

A modification of the above test may be made by washing the starch once or twice with water and then pouring the milky liquid into a long graduated 100 c.c. measuring glass, and allowing the starch to settle out. In every case the mixture of starch and water should stand exactly 24 hours. The amount of solid starch is noted. In each case the same weight of flour should be used.

The following table will give some idea of the proportions of the various ingredients contained in different kinds of wheaten flour.

	No. 1 Wheaten Flour.	No. 2 Wheaten Flour.	No. 3 Wheaten Flour
Starch.....	68'09	70'05	67'71
Gluten, dry	9'88	6'76	2'36
Glucose	4'93	5'17	8'55
Dextrin	3'51	4'11	7'39
Water.....	12'78	13'31	13'52
Mineral Matter	'81	'60	'47
	100'00	100'00	100'00
Moist Gluten	25'81	17'65	6'18
Quality of Gluten	good	good	very bad

TREATMENT OF FLOUR FOR SIZING.

When the starches, such as farina and maize, are examined under the microscope, it will be seen at once that the granules are separate and distinct, but when wheaten flour is examined in the same way, it will be seen that the starch granules are held together in groups. This is due to the gluten present in the flour, and, in order to separate the granules, it is necessary to rub the flour with water for some considerable time.

In the same way it is essential, before using the flour for making into size, that these starch granules shall be separated from each other, because it has been found by experience that the best results are obtained when the groups of starch granules are entirely broken up, so that each individual granule is distinct and separate from its neighbour. Yarn sized with flour in this condition is much smoother, and much more pliable, than if the size were made from untreated flour. For this reason it is essential that flour should undergo some preliminary treatment before being made into size.

Many very different opinions are expressed by sizers as to the methods to adopt in the treatment of flour in order to get the best results. In the past it was customary to ferment the flour for long periods, but this method of procedure is being rapidly superseded, *except for certain classes of "light" sizing*, by the more economical and more

scientific method of steeping with chlordide of zinc, whereby fermentation is prevented.

OBJECT OF FERMENTING FLOUR.

The process of fermentation is carried on by different manufacturers for varying lengths of time and with varying objects. Some manufacturers ferment their flour for periods ranging from one month to six months. Some carry out the process in order to prevent the yarn sized with it having a harsh feel, whilst others conduct it with the object of producing antiseptic substances, in order to prevent the development of mildew on the woven cloth.

There are certain manufacturers who possess a high reputation for China shirtings of a certain class. The warp in these shirtings is sized to the extent of about 30 per cent. without the use of mineral substances like China clay, and without the use of deliquescents like chloride of magnesium. The size consists of flour and tallow only. The cloth has a characteristic feel and appearance when woven, and many manufacturers would be glad to know the secret possessed by those who are engaged in manufacturing this class of cloth. The main secret is in the treatment of the flour before it is used. It is customary to ferment the flour for periods ranging from two to six months. The effect of this prolonged fermentation is to produce a size which renders the

yarn pliable, and gives a full mellow feel to the woven cloth.

It would be impossible to obtain good weaving results with yarn sized to the extent of 30 per cent., with flour and tallow alone, unless the flour had been previously subjected to a long process of fermentation. The reason is, of course, that the yarns would be so harsh and brittle that good weaving would be impossible.

Why flour fermented for a long time should give a much softer size than if it be fermented for a short time only, is a matter requiring explanation. In the first place it is due to the breaking up of the flour, and the separation of the starch granules, and in the second place it is due to the decomposition of the gluten, and at the same time to the production of greater or less quantities of soluble starch and sugar. This soluble starch and sugar is the result of bacterial action, and in its production the original starch loses its adhesive properties according to the amount of soluble matter formed.

It is customary for manufacturers who size the class of cloth under discussion to purchase flour containing as high a percentage of gluten as possible. They claim that from such a flour only can they get the right percentage of size on the warp with the desired degree of softness.

It is quite true that a flour containing a high percentage of gluten gives the results, but this is

because the nitrogenous gluten is an excellent medium for bacterial development, and the more gluten there is present the greater is the production of soluble substances. These soluble substances are absorbed by the yarn when the latter is sized, and although the flour has lost some of its adhesiveness and a great deal of its harshness in their production, it has not lost the power of adding weight, because the soluble matters are still present.

The foregoing is the true explanation of the results obtained by fermenting a highly glutenous flour for long periods, but in the opinion of the authors these results could be obtained equally well, if not better, by using a flour not so rich in gluten in conjunction with a soluble starch or white dextrin. If the flour be mixed with a definite amount of these substances the time required for fermenting could be reduced to three weeks or a month. This would mean that a considerable reduction could be made in the quantity of flour laid down at one time, and would save a considerable amount of beck space. It would be cheaper to add soluble starch or white dextrin to the size, thus saving the enormous loss in material which takes place during a long fermentation, for not only is soluble starch produced by this process, but some of it is further converted into alcohol, and acetic and lactic acids, as the fermentation is continued. The production of these latter substances is a distinct loss to the manufacturer, as they are

quite useless for sizing purposes. How much loss is entailed cannot be calculated, but in a year's working with a big firm it must be enormous.

If, however, the flour be fermented with the object of producing wheaten starch at a less cost than it can be bought from the dealers, and the production of wheaten starch, with more or less soluble starch is the real object of a lengthy fermentation, whether the sizer knows it or not, then it must be self evident that the most suitable flour to use for subjecting to this process will be one in which the wheat is well matured, and one which must therefore be rich in starch. The percentage of gluten may be fairly low so long as it is of high quality, and, as a matter of fact, it is impossible to get a condition where the gluten is of high quality and the starches of a poor quality.

If the manufacturer be also depending upon the antiseptic matters, he must boil up the flour with the water in which it has been fermented, but this is really a most objectionable method of preparing size. It usually has a most abominable smell which is imparted to the woven cloth, and makes the atmosphere of the weaving shed most trying to those unaccustomed to it.

There is no doubt also, that fermented flour is not so liable to develop mildew as unfermented flour. But this is due, in the first place, to the fact that the resultant wheaten starch, freed from the nitrogenous

gluten, is not, in itself, so suitable a medium for mildew growths as flour in its natural condition. In the second place, the antiseptic substances formed by the decomposition of the sugar and dextrin tend to prevent the setting up of mildew. At the same time the uncertain amount of antiseptic matter produced never pays for the loss of material and time, and if the production of antiseptics were the only object in fermenting flour, the whole matter would be an absurdity, as suitable antiseptics of known and definite properties, such as salicylic acid and carbolic acid, could be used to greater advantage.

Some manufacturers allow the starchy matter to settle, and run off the water. If this be done the whole of the antiseptic substances are lost. As a matter of fact the loss of the antiseptic substances produced by fermenting flour need never be considered at all, and where it is customary to run off the liquor in which the flour has been steeped, it is only necessary to boil the starchy matter with salicylic acid, in the proportion of four to six ounces of the acid to each 100 pounds of starch, to prevent mildew, and thus avoid the use of evil-smelling size.

It will be perfectly evident to the sizer that if he is going to ferment in order to manufacture his own wheaten starch, it will be more economical to purchase flour with a higher percentage of starch and a lower percentage of gluten, so long as the gluten is of good sound quality.

It would obviously be a mistake to use a flour containing, say, 15 per cent. of dry gluten if the manufacturer can get equally good results with one containing 6 per cent. The former flour would probably cost more than the latter, and would be more wasteful, because the amount of starch would be greater in the cheaper flour than in the dearer one. At the same time, the manufacturer must remember that a cheap flour, containing gluten of poor quality, is not suitable for fermentation. The starch is never of good quality, and very often putrefactive fermentation sets up, making the size very objectionable in smell, and liable to develop mildew on the cloth afterwards.

The authors often wonder to what extent this objectionable smell of putrid size has influenced the authorities in the matter of the ventilating of weaving sheds. The irony of the position will be appreciated when it is realised that, as a rule, these weaving sheds do not come within the Act relating to ventilation, because they do not use artificial humidity for assisting the weaving.

Where the process of fermentation is carried out, the manufacturer should insist upon the becks being thoroughly cleaned out with boiling water and washing soda, before a fresh lot of flour is laid down. The becks should afterwards be kept carefully covered over in order to prevent, as far as possible,

the spores of mildew getting into the flour at this stage. By careful attention to these details, after-troubles may be avoided.

All fermented flour contains varying quantities of acids. In some cases the authors have actually found the amount to be over one per cent. of the total mixture of flour and water. The presence of acids may be shown by dipping a piece of blue litmus paper into the mixture. If acids be present the litmus paper becomes red. These acids, which consist principally of acetic acid and lactic acid, should always be carefully neutralised with caustic soda. This is important for several reasons. In the first place acids have a strong tendency to cause the reeds in the looms to rust, thus producing iron stains on the cloth. Acid size will also act chemically upon the copper rollers in the tape frame, and the copper boil pipes in the sow box and in the becks. The copper is more or less quickly dissolved, and the copper solution tints the size green. This action may take place on some copper rollers and pipes, and might not have any action on others. A great deal depends upon the nature of the copper from which they have been made. Some copper rollers tarnish much more readily than others. This is due to the nature of the copper. The action of acid size is very noticeable on copper which is liable to tarnish. The acids readily attack the tarnished places, dissolving the tarnish, and the freshly exposed

surface readily tarnishes again when the tape frame is stopped. These fresh places are again acted upon by the acids, and if this is not attended to the roller will soon become worn out and useless. The writer has been frequently called in by manufacturers where this trouble has occurred, and in all cases it has been found that the size gave an acid reaction, due either to the flour, or to the presence of rancid or impure tallow in the mixing.

It is of interest to note that damage through the action of these acids may generally be minimised if each copper roller be carefully polished before being used, care being taken to remove every trace of tarnish from it. The following instance which came under the writer's notice some time ago, is a good illustration of this fact. The trouble had been going on for about ten days, and was causing considerable inconvenience. It was not convenient to neutralise the size (which was found to be acid) at the time of the visit to the mill, and so the roller was taken out for examination. On careful inspection it was seen that the corrosion was taking place in certain places only. A new roller was obtained, and the writer saw that it was thoroughly scoured and polished to remove every trace of tarnish. The old size in the sow box was cleaned out, and the roller put into position. The size was pumped in, and the operation of sizing the yarn was continued without any further objectionable

results. The old roller was then thoroughly scoured and polished, and afterwards used without the production of the green colour in the size.

An interesting case of damage, traceable to acid size, came under the authors' notice some months ago. A certain firm had been caused considerable loss and annoyance through the healds wearing out long before good healds should be affected at all. It was not a case of using inferior healds, nor was it confined to the healds of any particular maker. This trouble had been going on for a long time, until the manager commenced using caustic soda for the purpose of neutralising the acids of the fermented flour. This experiment was carried out without any expectation of its affecting the healds, but a change in the wearing of the latter was seen as soon as the first lot of beams were sent into the weaving shed, and, without making any other change, the damage was stopped. It is quite probable that very acid size will affect the varnish of the healds, and thus cause a large amount of breakages.

Caustic soda may be used for the purpose of neutralising acid in flour size. It is of the utmost importance that the caustic soda should be diluted with water as much as possible, otherwise it will coagulate the flour. The lumps thus formed are very difficult to remove, even on prolonged boiling. The diluted solution must be added in a thin stream to the size, which should be kept constantly agitated during the

operation by means of the dashers. When the acidity has been destroyed the blue litmus paper ceases to turn red on being dipped into the size.

If sizers had some knowledge of volumetric analysis it would be possible, in a few minutes, to ascertain the exact amount of caustic soda which would be required to neutralise the acidity of the size, and thus save continual testings with litmus paper.

The following method of procedure, although rough and ready, might be adopted in order to avoid the waste of time which would take place if the caustic soda be added without any idea of the amount required:—10 grammes of the size should be carefully weighed in a beaker. A few drops of phenol-phthalein is then added, and the mixture titrated with a normal solution of caustic soda, from a burette, until the last drop turns the size pink.

One c.c. of the solution of caustic soda contains 0.04 gramme of real caustic soda, and this number, multiplied by the number of c.c. used, and afterwards by 10, will give the percentage of caustic soda required to neutralise the size. This may be reckoned either in grammes or pounds to suit the convenience of the experimenter.

STEEPING WITH CHLORIDE OF ZINC.

The authors have already stated that the main object of fermenting flour, or of steeping it with

chloride of zinc, is to separate the starch granules from the gluten. This result may be obtained equally well by either process, but where there is no objection to the use of chloride of zinc in the size, there is everything to gain and nothing to lose by steeping with zinc.

The following are some of the principal advantages obtained by subjecting flour to the steeping process :—

(1) The gluten of the flour is retained, and its powerfully adhesive properties can be employed in assisting in fixing the China clay to the yarn.

(2) There is no loss in the starch, as is the case when the flour is fermented, and consequently the whole of the adhesive powers of the starch are retained for strengthening the yarn, and fixing the China clay.

(3) The size does not develop acids, and there is an entire absence of the disagreeable smell which is almost always present in fermented flour. Putrefactive decomposition is impossible in the steeping process, no matter how long the chloride of zinc and flour are left together.

(4) There is no risk of loss in the steeping process through the contents of the beck overflowing, as is very often the case where the flour is fermented, especially in hot weather.

(5) There is less chance of the chloride of zinc being omitted from any single mixing where the

steeping process is carried out, than is the case where the chloride of zinc is added to every mixing separately. This is a consideration of the utmost importance, as many cases of mildew come under the authors' notice which are entirely due to the chloride of zinc having been left out of a mixing through a lapse of memory on the part of the size mixer.

(6) Where the steeping process is carried out, the flour, which is the substance most liable to mildew, is brought into direct and intimate contact with the substance which is used for the purpose of preventing mildew. A further consideration is, that the chloride of zinc becomes intimately mixed with the starch granules before its antiseptic action is diluted through the addition of the other ingredients of the size.

(7) Chloride of zinc has the power of acting upon the gluten of the flour, and the cellulose of the starch, in a similiar manner to mineral acids, and in consequence the starch granules are quickly separated, thus bringing the flour into the condition in which it is suitable for use in a very short time.

(8) Less beck space is required when the flour is steeped with chloride of zinc because more flour can be put down at one time in a beck of a given capacity, as there is no danger of overflowing.

(9) Greater uniformity in the strength of the size can be maintained when the flour is steeped with zinc. As there is no chemical change, and no

loss through the production of sugar, alcohol and acids, the flour remains at a constant standard of strength. Therefore, instead of depending upon the strength, as tested by the number of degrees the mixture of flour and water may Twaddell, the size mixer simply runs off so many inches of the mixture to the weight of dry flour he may require for a mixing.

Where the steeping process is carried out the flour should remain in contact with the water and the chloride of zinc for about a fortnight. In this time it is rendered fit for use. The quantity of chloride of zinc which should be used per pack of flour (280 lbs.), is from $3\frac{1}{2}$ to 4 gallons, at 100° to 102° Tw. This matter is further discussed under chloride of zinc, and also in the chapters on size mixing and mildew.

USE OF WHEATEN FLOUR IN SIZING.

Wheaten flour is undoubtedly the best adhesive substance to use for all-round work in sizing, and where weaving is the first consideration, it cannot be improved upon. There are, however, certain cloths in which a particular "feel" and appearance is required, and these conditions can be better obtained by the addition of one or other of the various starches. This is a matter which will be more fully dealt with when these starches are discussed.

It is often suggested that flour might be abolished altogether from sizing, and a pure starch such as farina

substituted, because this substance does not develop mildew to the same extent as a nitrogenous body like wheaten flour. In the authors' opinion there is nothing better than flour for medium and heavy sizing. With regard to mildew, this is not a matter worth considering at all, as mildew can always be avoided by the proper use of antiseptics.

It is a constant source of complaint that a size mixing, supposed to produce a certain weight and feel, does not give the same results in the hands of one manufacturer as it does in the hands of another; even where exactly the same method of procedure is adopted in mixing.

If the same weights *and qualities* of the various ingredients are used, and if exactly the same treatment is accorded, it is impossible to get different results. The explanation as to why differences occur is that two firms rarely use the same "standards" in their materials. The two substances which most affect the character of the size are the flour and the China clay.

The writer has always had to contend with this difficulty in laying down mixings, and, unless the strength and character of the flour and the nature of the clay be known, a mixing is bound to vary in different hands. This is the reason why size mixings given in books should be taken as a working basis only. If flour of a regular strength and China clay of a regular quality could always be obtained it

would not be a difficult matter to keep size mixings uniform. A miller, who knows his business as far as sizing flours is concerned, may, by the judicious mixing of various classes of flours, always be in a position to supply a flour which is constant in strength. In technical language he will "standardise" his flour.

The importance of conditions such as these cannot be over-rated, and, until manufacturers realise this fact, there will always be a want of uniformity in the results obtained, however much care may be exercised in making the size. This is the explanation why a certain mixing may be successful at one mill and may not work well in another.

FARINA OR POTATO STARCH.

Farina is obtained from the tuber of the potato plant (*solanum tuberosum*). The potato consists principally of starch and water, fully 75 per cent. of the latter substance being present in the average sample. Under careful cultivation the potato may be got to yield about 20 per cent. of starch.

Farina has a peculiar glistening appearance and is much crisper to the touch than any of the other starches. This crispness depends, to a great extent, upon the amount of moisture present in the sample, the crispness decreasing as the moisture

increases. Farina forms a semi-transparent paste when boiled with water, and by this characteristic appearance it may be distinguished from the other starches used in sizing. Weight for weight it produces a thicker paste than any other starch except maize.

The following analysis shows the average composition of the potato under careful cultivation :—

					Per cent.
Starch	...	...	...	...	20'00
Fat or Oil	...	...	...	...	0'10
Cellulose	...	...	...	...	1 55
Gum or Sugar	...	...	...	...	1'05
Nitrogenous Substances	..	...	...	...	2'27
Ash ...	...	...	...	...	1'02
Water	...	...	...	...	74'01
					<hr/>
					100'00
					<hr/>

Although the potato contains so much less starch than wheat the product of starch per acre is greatly in favour of the former.

MANUFACTURE OF FARINA.—Few operations are more simple than the extraction of starch from potatoes, nothing further being necessary than the rupturing of the cellular tissue by rasping or grating, thus liberating the starch granules. The pulp obtained is washed upon a metallic plate or stage, by means of a stream of water, and the washings passed through a sieve. The solid matter of the potato is left on the plate, whilst the sieve separates

the other impurities. This sieve allows the starch to pass through, which is carried forward by means of the water. The starch is further purified by washing and decantation. The operations involved in the process are further detailed as follows :—

STEeping THE POTATOES.—This is done previous to washing, for the purpose of softening the earth and clay adhering, and so rendering the washing process more easy. The potatoes are steeped in a large trough from six to twelve hours, according to the amount of impurities.

WASHING.—This operation is effected by mechanical means, and by the aid of steam.

RASPING OR GRATING.—The object of rasping is to reduce the potatoes to a pulp, so rupturing the cell walls containing the starch granules.

The more thoroughly this rasping is effected, the easier it becomes for the starch to escape. As a general rule the washing and rasping processes are conducted in a machine which allows the operations to proceed consecutively. The starch, having been washed by means of a stream of water, is purified by first allowing the liquid to settle for a few hours. The supernatant liquid is removed by syphoning, and the starch residue is mixed with its own bulk of water, and passed through a series of fine sieves to remove stones, sand, and other impurities. It is again allowed to settle, the liquid syphoned off, and the solid starch re-agitated with fresh water, and

either passed through a very fine brass wire sieve, or filtered through silk. The liquor is again allowed to separate from the starch and it is then removed, leaving the starch ready for drying.

DRYING.—This operation is a very necessary one, as starch retains a large amount of moisture. The starch is first placed in the form of solid blocks on beds of plaster of Paris, which absorb a large amount of the water. The blocks of starch are further dried in heated chambers, through which a current of fresh air is being constantly passed. The temperature of these chambers should never exceed 212 degrees Fah.

Germany and Holland are the principal countries in which the potato is cultivated for the extraction of starch. In Germany particularly, the cultivation has been carried out to a high state of perfection, and German farinas are superior to any other. So greatly does a good farina differ from a poor one, that it is possible for the expert to determine, by the microscopical appearance of the starch granules, whether the starch be Dutch or German. In the latter case the granules are composed of evenly-formed medium-sized corpuscles, whilst in the former they are very irregular in size, being composed of large and small corpuscles. Farina consisting of regular-sized granules is invariably the best for sizing purposes. It produces the thickest paste on boiling with water, and the paste is not so liable to liquefy

as that formed by farina composed of irregular-sized granules. This is a matter of vital importance in sizing as it would mean that if an inferior grade of farina should be used the yarns sized with it would very quickly become "soft," giving rise to the state known as "soft beams." This would be more especially the case where the beams had to remain in the weaving shed for a lengthy period.

The reason why Dutch farina is more liable to produce "soft beams" than German farina is because it is more susceptible to bacterial action. This may be accounted for in several ways. In the first place the question of cultivation must be taken into account, and in the second place the nature of the soil, and the nature of the water used in the preparation of the farina, must be considered. It is highly probable that the starch developed in a potato in a damp soil like that which characterises Holland secretes nitrogenous matter in the granule. This will render it more susceptible to bacterial action. That the water used in the preparation of the farina may account for this liability to bacterial attack is already recognised, as some of the Dutch firms are now using distilled water instead of ordinary water. The authors have previously mentioned that the starches most liable to liquefy, after being made into pastes with boiling water, are those which are developed underground, and that this characteristic is not shown to the same extent in those developed above ground

such as the starch from seeds, and the pith of plants. This goes to support the authors' contention that the character of the soil in which the potato has grown plays a most important part in the question of the liability of any particular sample of farina paste to bacterial action.

Size made from farina will not stand prolonged boiling. Under this treatment it quickly loses its adhesiveness. Unfortunately it is impossible to ascertain, by any simple test, the amount of loss of strength, and consequently size left overnight is either thrown away or more farina must be added to approximately make up the loss. Whatever is done leaves the sizer in a most unsatisfactory position. If he throws away the old size he is suffering daily loss, and if he adds more farina he is put to an expense which ought not to occur, and the size is uncertain in strength.

This objectionable feature has been overcome to a great extent by treating farina size with caustic soda. By experiments in the laboratory it was found that farina treated with this alkali would keep its adhesiveness for a great length of time.

The following description gives the details of the experiments:—Seven grammes of the farina were carefully weighed, and mixed with 200 cubic centimeters of water in an evaporating basin. The mixture was boiled for half-an-hour on the water bath described on pages 55 and 56, and set aside to

cool. Another portion from the same farina was treated in a similar manner, but with the addition of one per cent. of caustic soda. The following day the two samples were boiled up again. The first showed signs of liquefaction, but the second showed no change. The boiling was continued day by day for a week, an equal quantity of water being added in each case to make up for loss by evaporation. The samples were then allowed to stand. At the end of three more days the sample which had not been treated with caustic soda was liquid, and covered with yellow and purple mildew, whilst that containing caustic soda was firmer than was the sample of paste boiled *without* the caustic soda originally, and, although they had stood exposed side by side, the former sample did not show the slightest trace of mildew after being exposed for a further period of six weeks.

The manufacturer will see, therefore, that not only does caustic soda preserve the strength of farina size, but, by its action in preventing the decomposition of the starch through bacterial action, and thus preventing the formation of acids which would otherwise be left as free acids, it acts as an antiseptic, preventing the development of mildew.

Since making these laboratory experiments, the writer has supervised the treatment of farina size in many mills with the same success. Caustic soda has the further advantage of not being injurious in

any way to cotton. It does not affect it disadvantageously for bleaching, rather the reverse. At the same time it must be used judiciously, otherwise a little trouble will ensue. The first use of the caustic soda should be made under expert supervision, and afterwards no fear of trouble need be felt.

If the above treatment be carried out, larger quantities of farina may be laid down at one time, and the size kept much more uniform. The loss of strength in the mixture will be prevented, making a very considerable saving at the end of a year.

In the summer it is necessary to add a greater percentage of caustic soda, especially where the size is standing over the week-end, say from Friday to Monday. This is more particularly the case during close and thundery weather. Under such conditions acid is developed rapidly, just as beer and milk are soured, and unless an extra quantity of alkali be added, the acid may be sufficient to entirely neutralise the caustic soda present, and by Monday a sour size, with a loss of strength on boiling up, will be the result. The alkali requires using in an intelligent manner to get the best results.

Since the first edition of this book was issued nine years ago, caustic soda has come into general use for sizing purposes. The authors claim to be the first to point out the special advantages of this substance in preventing "soft beams" when used with farina. It is therefore, somewhat amusing to

find the matter being periodically re-discovered, and either offered free to the world at large, from motives more or less philanthropic, or sold, in the form of some secret and mysterious preparation, generally as a liquid, or in the form of a watery soap containing a certain amount of free alkali, at a price considerably in excess of the value of the active ingredient.

DETERMINATION OF THE VALUE OF FARINA.

COLOUR.—Farina intended for sizing purposes should be of good colour. Dark samples will impart their shade to the cloth, and where whiteness is required, such a sample would be very objectionable.

MOISTURE.—Farina contains a larger amount of water than any of the other starches. This varies from 17 to 20 per cent. It is always advisable to estimate the quantity of moisture present, following the method of procedure given on page 23. Everything else being equal, the farina having the least percentage of water should be chosen.

STRENGTH OF FARINA PASTES.—A suitable test for the quality of a sample of farina is made by comparing the strength of the paste, formed on boiling it with water, with a standard sample of good quality. The process has been given under flour on pages 55 and 56, but in the case of farina, seven grammes of the starch should be used to 100 cubic centimeters of water. If the proportions given under

flour were used, a paste is formed which is too thick to determine the quality or difference in stiffness to a nicety.

It is necessary to carry out this test further, and notice whether liquefaction takes place on standing. A paste made from a good farina should not liquefy, but, on exposure, it should dry up. Inferior farina forms a paste which will liquefy in two or three days, according to the atmospheric conditions.

MINERAL MATTER.—Mineral matter is almost entirely absent in farina. The average amount found by the analyses of a large number of samples was 0·2 per cent. The percentage of ash may be found by burning the farina in a weighed crucible, as described on pages 61 and 62. Mineral adulteration may be readily detected by shaking up a portion of the farina with chloroform, as described on page 63.

USE OF FARINA IN SIZING.

Farina is used chiefly for pure and light sizing, although it may be used in conjunction with sago and maize for the heaviest sized goods.

In pure sizing farina gives a smoothness and pliability to the yarn which is not excelled by any other starch. The colour of the cloth is also whiter than when flour or sago is used.

Farina may be used, without the addition of any other starch, for heavily picked goods if the *best qualities* are selected, but, as has been previously

stated, there is a marked tendency for farina to lose its strength, both when mixed in the size beck, and afterwards on the weavers beams, if the latter have to remain in the weaving shed for a long time. In the case of very heavily picked cloths, this is always so, and there is in consequence the ever present danger of the yarn becoming "soft" before it is woven out.

In order to reduce this tendency to "softening," it is advisable to use a mixture of sago and farina for all heavily picked goods, or, if farina be used alone, $\frac{1}{4}$ to $\frac{1}{2}$ per cent. of solid caustic soda should be added to the weight of starch employed, as previously described on page 92. The alkali should be dissolved in the water, and the farina afterwards mixed with it.

SAGO FLOUR.

Sago is the name given to the starch which is derived from the pith of several kinds of palms, the principal of which are:—*sagus rumphii*, *sagus farinifera*, *borassus flabelliformis*, and *arenga saccharifera*. The palms are allowed to grow to a height of from 20 to 30 feet, before any of the starchy matter is extracted. When the tree is cut down and the top severed from it, it forms a cylinder of about 20 inches in diameter, and from 15 to 20 feet long. This cylinder consists of an outer woody tube in which the pith is enclosed. Such a tree as here described will yield about 700 pounds of starch,

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and three such trees would yield as much starch as one acre of wheat.

The starch is extracted from the pith, which is a mixture of starch and fibrous matter, by washing, etc., in the manner described under farina.

When sago arrives in this country, it generally contains a quantity of foreign matter which it is advantageous to eliminate before it is used for sizing purposes. To effect this separation it is usual to dress or sieve the raw sago. The process consists in passing it through a miller's silk, by which means the foreign matter is removed. The sago is then known as "dressed sago." There are several qualities of sago sold for sizing purposes. They vary both in strength and colour. Sago contains, as a rule about 14 to 15 per cent. of moisture.

In determining the quality of a sample of sago, it should be tested for consistency of paste, as described on pages 55 and 56; for moisture, as described on page 23; and for mineral matter, as described on pages 61 and 62. This latter test is very necessary, as sago frequently contains a quantity of silica in the form of fine sand. This is a very objectionable substance to have present in a starch like sago, which is used almost entirely for light sizing. The effect of this impurity would be to cause a rapid destruction of the healds and reeds. The presence of gritty particles will be readily detected when the starch is being prepared for

examination under the microscope on account of the scratching effect shown when the sago is rubbed up with water on the glass slide by means of a glass rod.

Sago should also be tested for chloride of sodium (common salt). The presence of this substance indicates damage from sea water.

USE OF SAGO IN SIZING.

With the exception of tapioca, sago starch makes a thinner paste than any of the other starches used in sizing. It is used principally for pure sizing, and more particularly for heavy picked goods, where sizing is conducted for the purpose of giving the greatest possible strength to the yarn with the least possible amount of size.

Sago has a greater tendency to strengthen the yarn than farina, and, unlike the latter starch, it appears to be free from the tendency to lose its strength after being mixed. Yarn sized with sago flour will retain its strength for months.

When sago is used for light or medium picked goods it may be mixed in the same way as farina; but when it is required for strong picked cloths and fine reeds, it must be treated in a different manner. These goods require a greater percentage of size in order to withstand the increased friction in weaving, and consequently a stronger size must be used. If a strong mixing of sago be treated in the same way

as farina, the yarns would be rendered hard and harsh, with a tendency to become brittle. In this condition they would quickly destroy the healds and reeds on account of the cutting or filing action.

In order to overcome this harshness, and consequently prevent the rapid wearing of the healds and reeds, it is necessary, in sizing the last named class of goods, to boil the sago for a few hours in the beck before using it in the tape frame. By this means a greater degree of softness, and an increased pliability in the yarn is obtained, and the objectionable properties of the sago are destroyed. There is no risk of sago size losing its strength by prolonged boiling, such as occurs with farina. As a matter of fact some of the heaviest picked goods produced in the cotton trade are sized with strong sago mixings, which are kept boiling gently all the day in the beck from which the taper uses his size.

Caustic soda may be employed to advantage with sago. It helps to break up the granules into finer particles, and besides making the starch more adhesive, it also deepens the colour of the mixture. This might be objectionable for American yarns, but it gives Egyptian yarns a much better appearance. The amount of caustic soda to use for each 100 pounds of sago is from $\frac{1}{4}$ to $\frac{1}{2}$ a pound of the solid alkali. The alkali should be dissolved in the water

used for making the size, and the sago afterwards mixed with it.

For sizing coloured dhootie borders, sago is much more suitable than farina. This is especially the case where narrow borders are being run, because it takes a long time to use up the size where there are a few ends only. In consequence of this, the strength of the size in the coloured box is gradually reduced on account of the amount of condensation which takes place. Not only is the strength of the size reduced by condensation, but in the case of farina the prolonged boiling would affect the strength as previously mentioned.

MAIZE.

Maize is obtained by grinding the seeds of the *zea mize*. Like wheaten flour it is a complex substance, consisting of starch, gluten, sugar, dextrin, albumen, and mineral matter. The following analysis shows the average composition of maize flour:—

	Per cent.
Starch	53·8
Gluten	8·2
Cellulose	13·4
Gum and Sugar	2·9
Fat and Oil	4·7
Ash	4·8
Water	12·2

100·0

Maize starch is obtained from the ground maize. This substance is not readily separated from the gluten with which it is combined, and, in order to effect the separation, it is necessary to treat the ground maize with some chemical, such as caustic soda, or hydrochloric acid. These substances break up the combination and liberate the starch. The starch may also be separated by fermentation, but this process is very objectionable on account of the disagreeable smell produced by the decomposition which takes place.

Maize starch usually contains about 13 to 14 per cent. of moisture, and less than one per cent. of ash. It resembles farina in one respect, *i.e.*, it produces a very thick paste on boiling with water. This paste differs from farina paste in being opaque, like that obtained from wheaten starch, whereas farina paste is translucent. Maize starch paste differs also in character to that obtained from wheaten starch. In the former case the paste is of a granular nature, whereas in the latter case a very smooth paste is formed with the same amount of boiling.

Maize starch paste does not liquefy on standing, nor does it lose strength after being repeatedly boiled. It is worthy of note that this paste in the absence of antiseptics, will mildew, under the same conditions, much sooner than the paste made from any of the other starches.

" In determining the quality of maize starch, it

should be tested for colour, as described on page 54; for consistency of paste, as described on pages 55 and 56; for mineral matter, as described on pages 61 and 62; and for moisture, as described on page 23. Maize starch varies considerably in colour, and for sizing purposes it is advisable to employ a starch of good colour.

USE OF MAIZE STARCH AND MAIZE FLOUR IN SIZING.

MAIZE FLOUR.—Maize *flour* is used only occasionally for sizing purposes. In recent years it has been used largely as an adulterant of wheaten flour. Probably no more unsuitable substance could have been chosen for the purpose, and the authors utterly condemn the practice. The reason why it is not a suitable substance to use for sizing purposes is because it is not easily gelatinised by boiling. In consequence of this, maize flour produces a dusty mixing because, in the first place, the ungelatinised particles of flour possess little or no adhesiveness, and, in the second place, on account of their roughness, these ungelatinised particles rub off when subjected to the friction of weaving. A sizing flour containing maize flour will not carry China clay anything like as well as a pure flour. Only recently a case came under the writer's notice where a firm of manufacturers were putting 200 per cent. of size on the twist in order to get a certain weight in the

woven cloth. The writer got a greater weight in the finished cloth with 50 per cent. less size. The result was obtained by using a pure flour instead of one containing maize flour, and also by using a better China clay than the one previously in use. The explanation why the mixing laid down by the writer gave a greater weight of size on the cloth than the one containing 50 per cent. more size is simple. In one case the size stuck on the yarn, whereas in the other case it rubbed off. The change meant a considerable saving to the manufacturer because he got the desired results at a much less cost. The unsuitability of maize flour for sizing purposes is further discussed under maize starch.

MAIZE STARCH.—Maize starch, or corn starch as it is very often called, is used chiefly for medium and heavily sized goods, in conjunction with wheaten flour. A mixture of wheaten flour and maize will give a better appearance, and a harder and firmer feel to the cloth, than can be produced with wheaten flour alone. If, however, too much maize starch be used it tends to make the yarns very brittle. Dealers in so-called sizing flours use maize starch very largely to mix with wheaten flour. The proportion generally employed is three or four parts of wheaten flour to one part of maize starch.

As previously stated, the authors do not advocate the purchase of such sizing flours. It would be

more preferable to buy a pure wheaten flour, and mix it with maize starch as required. This would lead to better and more economical results, and it would leave the manufacturer quite independent of the dealers. An instance of the danger of this dependency upon the dealer in flour mixtures was shown some years ago. A certain manufacturer had been in the habit of knowingly buying his flour mixed with 20 per cent. of maize starch. In one delivery the dealer substituted *maize flour* for the starch. The result of using this was that mildew developed on the cloth sized with it. The mildew was caused by the *maize flour* not being properly gelatinised in the boiling process, and in consequence the chloride of zinc never got properly into contact with the starch granules of this substance. These granules afterwards developed mildew in the form of little yellow spots, and when an examination of these spots was made, maize starch granules were found in an unbroken state. This would not have happened had the flour dealer continued to use maize starch instead of substituting the maize flour for it.

Maize starch, itself, requires thoroughly boiling in order to ensure the proper breaking up and gelatinisation of the starch granules, and unless this boiling is prolonged the size will produce a rough feel, and a reedy appearance on the cloth. Maize starch must be thoroughly cooked before applying it to the

yarn, otherwise it is possible to detect, by means of the microscope, unbroken granules of the starch in size which has been washed from cloth containing it.

The best method of treating maize starch for medium and heavy sizing, is to boil it in the clay pan along with the China clay. An improved method would be to add half-a-pound of solid caustic soda, previously dissolved in a bucketful of water, for each 100 pounds of maize starch. This would not only produce a smoother feel, but it would render the starch much more adhesive.

N.B.—Caustic soda should not be employed where the clay is boiled along with chloride of magnesium, as chloride of magnesium and caustic soda decompose each other.

Maize starch is not often used in pure or light sizing. In cases where it is employed it must be boiled for at least two or three hours before it is pumped to the tape frame. China clay will counteract the natural harshness of maize starch in a light size mixing, but a greater percentage of size has to be put on the yarn in order to get this "softness," than would be the case if either farina or sago were used without the addition of China clay.

If maize starch could be subjected to some treatment which would give it the characteristic properties of wheaten starch, there would be a ready market for it. It has one great advantage, and that is its low price as compared with wheaten starch.

There is room for investigation in this matter, and the authors think that caustic soda could be successfully employed to get the characteristic "softness," without loss of adhesiveness, if only size mixers could be trusted to neutralise, or nearly neutralise, the excess of alkali required to carry out the operation successfully, by means of some acid such as acetic acid, or even sulphuric acid.

Experiments have been carried out with the view to producing this "softness" in maize starch by first treating it with nitric acid, and afterwards subjecting it to dry heat. The temperature at which the operation is conducted must not be high enough to convert the starch into dextrin.

TAPIOCA OR CASSAVA STARCH.

Tapioca is obtained from the roots of several plants of the *genus manihot*, the most important of which is *jatropha manihot*, a native of Brazil. This starch is also known as Brazilian arrowroot.

Tapioca has never been used very extensively for sizing. It produces a very thin paste on boiling with water, and, like farina, it loses strength with prolonged boiling. During 1905, it was used probably to a greater extent than at any other time. This was largely due to the high price of farina, and many manufacturers employed it as a substitute for the latter starch, but not with any great amount of success.

Tapioca was also used very extensively for adulterating farina and sago during this period, and this objectionable practice led to many manufacturers suffering considerable damage. This was especially the case where tapioca was used to adulterate sago, as in this case the mixture was used for pure sizing heavily picked goods, in which great strength is a most important factor. The consequence was that in many cases "soft beams" were produced, and a great deal of annoyance was caused.

Tapioca has few claims upon the sizer, and the authors merely give it a place in this volume because it is occasionally used for certain purposes. The chief use to which tapioca may be put in the textile trade, is the production of white dextrin for light finishing. For this purpose the weak character of tapioca is not objectionable, because in finishing, the cloth has not to be subjected to any strain, such as it undergoes in a process like weaving. This is a point many people do not realize. They think that because tapioca is suitable for light finishing it must be equally suitable for a preparatory process like sizing, but this is fallacious.

RICE FLOUR.

Rice flour is prepared by grinding the seeds of the rice plant "*oryza sativa*." This substance is the richest of all the cereals in starch, but, like maize, the starch is so intimately connected with the gluten

that it requires the action of chemicals, such as mineral acids, or caustic soda, to bring about a separation. This separation of the starch from the gluten can also be brought about by subjecting the ground rice to fermentation in water, but the process is an objectionable one. The following table shows the average composition of rice flour :—

	Per cent.
Starch	78.23
Fat	0.74
Cellulose	3.06
Gum and Sugar	0.45
Gluten and Albumen... ..	6.80
Ash	0.81
Water	9.91
	<hr/>
	100.00

Rice flour is chiefly used in sizing for the purpose of obtaining a harsh sharp feel in medium and heavily sized cloths. It is frequently mixed with wheaten flour by vendors, who make a speciality of supplying "sizing flours" for special requirements. As previously stated, it is most difficult to thoroughly break up and separate the starch granules of rice flour. It requires quite as much, if not more, boiling than maize flour or maize starch, to render it fit for giving good weaving results.

If rice flour be purchased ready mixed with wheaten flour, the process of fermentation, or of steeping with chloride of zinc, is sufficient to

separate the starch granules, but the best way of treating rice flour, if it be used at all, is to buy it separately, and mix the required quantity with the water in the clay pan. It should then be boiled for a few hours with the China clay.

Where a harsh rough feel is desired in the cloth, and it is desirable to use rice flour in conjunction with wheaten flour for its production, the most suitable proportions are one part of rice flour to eight of wheaten flour. This mixture will give a "feel" to the cloth which neither wheaten flour, or a combination of wheaten flour and maize starch will produce.

RICE STARCH.

Rice starch, itself, is rarely employed for sizing purposes. Rice flour is sufficient for all purposes. Rice starch is very extensively used in laundries for stiffening collars and cuffs. It makes these goods firmer, and the starch takes a higher polish than any of the other starches. This effect is due to the smallness of the granules of rice starch. Considering the low price of rice, it is remarkable that dealers can maintain such high prices for laundry starch in this country.

SOLUBLE STARCH.

Soluble starch, under various fancy names, has been put on the market within recent years. It is

manufactured by many different methods, and principally from maize starch or farina, or from mixtures of the two starches. Tapioca is also used for its production, either alone, or mixed with other starches.

Most of the methods in use for producing soluble starch are patented processes. Only those which are of interest will be described.

One of the earliest patents for the manufacture of soluble starch was that of Kanterowitz and Newstadt, which was granted in 1895. The process consists in dissolving starch in a solution of caustic soda, afterwards neutralising the alkali with sulphuric acid, and finally precipitating the starch by means of sulphate of magnesium. The precipitated starch is afterwards washed and dried.

In another process the starch is treated with dilute nitric acid containing free chlorine. The acid is removed by means of a centrifugal machine, and the starch afterwards dried at about 180° Fah. This method was originated by Siemens and Halske. Other acids, such as sulphuric, hydrochloric, and some of the organic acids, particularly formic, may be substituted for the nitric acid.

One of the most recent developments in this direction is the production of a soluble starch, to which the name of "Colloid" starch has been given by the patentees, Messrs. Browning & Barlow. This starch is prepared by submitting various starches to

the action of gaseous acids, for certain definite lengths of time, and at certain definite temperatures, according to the particular starch undergoing treatment. The acid vapours are afterwards neutralised with gaseous ammonia.

Powerful oxydising agents, such as hypochlorite of sodium, persulphate of ammonium, and chlorinated lime, have been used for the production of soluble starch, and patents have been taken out for most of the processes. Ozone has also been employed for rendering starch soluble. In this process, agar-agar (a form of sea-weed) is the source of the starch. The agar-agar is first moistened, and afterwards treated with ozone. The ozone is generated by an electrical apparatus.

Another process patented by Professor Dr. Alex. Classen, in Aachen, consists of heating starch to 180° F. under pressure in suitable vessels with sulphurous acid gas, SO_2 . The starch is afterwards subjected to the action of air or oxygen, or to some liquid containing oxygen. After being treated as above, the starch is again heated to 230° or 235° F.

The same Professor has also a claim on a patent process for converting the cellulose of wood into soluble starch and sugar. In this process the wood, or other similar material, is treated with water containing chlorine, and afterwards with sulphurous acid gas, SO_2 . Neither of these processes has yet been

successfully applied in practice, as they are too complicated.

A new process for preparing soluble starch was patented by Rellmas in 1897. It consists in treating starch with a 2 per cent. solution of either sulphuric, nitric, or hydrochloric acid at *exact temperatures*. The starch is afterwards washed to free it, as far as possible, from acid.

The objection to this method, and to all other methods where acids are used, is that great difficulty is experienced in completely removing the last trace of acid. If acids be left in starch intended to be used for sizing, or for finishing dyed goods, the results might be disastrous.

Another objection to these methods is, that it is impossible to fix exactly the point of chemical change from ordinary starch to soluble starch. If the oxidation has gone too far there is a loss of starch due to the formation of sugar and similar products. It is of course essential that there shall be as little loss of material as possible in the manufacture of soluble starch, otherwise the product is going to be too costly to be of any practical use.

A recent process for the manufacture of soluble starch, by the use of which the patentees claimed to be able to effect great savings to manufacturers, came under the authors' notice a short time ago.

The process, which was patented in this and other countries, was found to consist, when first introduced by the patentees, in treating the flour or starch with a so-called secret solution. This solution consisted of chlorinated lime (ordinary bleaching powder), dissolved in water.

The bleaching powder solution was discarded after some costly experiments and a solution of hypochlorite of soda was used in its place. This solution was covered by a fresh patent and worked in the name of another firm. In neither case is the patent a good one because the authors made the first process public years before the patentees appeared on the scene, and, in the case of the hypochlorite of soda solution, the writer gave the secret to several English firms of chemical manufacturers and cotton manufacturers whilst the patentees were still using the bleaching powder solution. Not only is there no patent right in the process but there is absolutely no benefit to be derived from it which cannot be got in a better and cheaper way. It may have been *indirectly successful* in some few cases, but the same benefits could have been got by an alteration in the proportions of the ingredients of the size mixing. The explanation of this is given herewith:—A great many manufacturers in Lancashire are using unnecessarily expensive size mixings, especially for heavy sizing. In most cases the excessive cost of these mixings is due to

the fact that too large a proportion of flour or starch is used as an adhesive substance to carry the China clay. When this is the case an excessive amount of tallow is required to soften the mixing. If, instead of using a *secret* process (for which exorbitant prices is asked), the manufacturer would reduce the proportions of flour or starch in a given mixing, where it is in too large an amount, he would, at the same time, be able to make an enormous reduction in the amount of tallow required to soften the size.

The action of bleaching powder solution and hypochlorite of soda solution on starch is to convert it into dextrin. This has the effect of destroying the adhesiveness of the starch to a considerable extent, the amount of destruction depending upon the amount of solution employed.

It will be at once apparent that if a size mixing contains an excessive quantity of flour, and a large proportion of the flour is destroyed by some treatment, the mixing will require less tallow to soften it than would be required whilst the flour existed in its original state. On the other hand, if less flour or starch had been employed originally, less tallow could have been used to get the same degree of softness.

The fact that so many size mixings contained flour and tallow out of all proportions to what was actually needed gave the German process an opportunity for success. Where the great mistake was

made was in trying to use the process in the case of properly proportioned mixings. In such mixings where the flour was present in quantity sufficient to carry the China clay and give the necessary strength to the yarn only, any destruction of the adhesiveness of the flour would be certain to cause trouble, because the flour would not then be sufficiently adhesive to cause the clay to adhere to the yarn. The consequences would be the production of dusty mixings, light cuts, and soft beams in the weaving shed.

From what has been said it must be evident that it is better to have a size mixing put on a scientific basis, than to trust to some secret, haphazard, and costly process which depends for its success on the destruction of the adhesiveness of the flour. It is better to use less flour in a mixing than to use an excessive amount and afterwards pay for its destruction by some costly and secret process. There are no secrets in successful sizing, only the application of common sense. When the success of a mixing depends upon the dropping into it of a pinch of something carried in the waistcoat pocket, it may be looked upon as merely "bluff."

Soluble starch may be prepared by boiling farina with a strong solution of chloride of calcium. When properly prepared this substance is of the consistency of rubber.

Starch of a more or less soluble nature is formed when strong solutions of chloride of magnesium or

chloride of zinc are boiled with starch. This operation renders the resultant starch paste much more adhesive than when starch is boiled with water alone, and chloride of zinc or magnesium afterwards added to it in the ordinary way of mixing.

The action of the above chemicals has been turned to account by dealers in sizing ingredients, and there are a great number of special sizing substances on the market which are neither more nor less than starch boiled with one or other of these chemicals.

Soluble starch may be prepared by triturating starch with sharp sand or broken glass. The result of this action is to disintegrate the starch granules, thus liberating the granulose. The granulose may afterwards be extracted with cold water.

Soluble starch, as previously stated, may be prepared by the action of the diastase of malt on starch. The operation requires conducting with care, otherwise the starch is converted entirely into dextrose and maltose, substances which are almost entirely devoid of adhesive properties.

A sample of so-called soluble starch, in which malt was the active ingredient used to render the starch soluble, was recently examined by the authors. It was found to consist of a mixture of maize starch and farina, to which finely powdered malt had been added. The starch was directed to be steeped in hot water for a short time before using. A remarkable change is found in the properties of the

starch after this treatment. The mixture boils thin, and it no longer shows the reaction of starch with iodine.

Previous to steeping in hot water, this variety of soluble starch has exactly the appearance of farina or maize starch under the microscope, depending of course upon which has been used in its manufacture, and no doubt this substance has caused much trouble to analysts where it has been simply subjected to a microscopic examination. That it is not simply farina or maize starch may be determined by allowing a portion to steep at a temperature of 140° Fah., for about an hour. A solution of iodine should then be added to the mixture, when it will be found that it no longer shows the starch reaction.

It has been found that different starches require different quantities of powdered malt to convert them into a soluble state when treated in the manner described on page 115. Farina and tapioca require about $2\frac{1}{2}$ per cent., whilst maize starch and rice require at least 5 per cent. The best method for the sizer to adopt in treating starch with malt in order to produce soluble starch, is the following:—

The starch, to which the powdered malt has already been added, is mixed with the required quantity of water. The mixture is then carefully heated until it begins to thicken, after which the steam is turned off, and the mixture allowed to stand for about 12 minutes. It should then be boiled up as quickly as possible.

It is necessary to exercise the greatest care where diastase in the form of malt is employed for the purpose of producing soluble starch, otherwise the operation may be carried too far, and the starch will lose its adhesiveness almost entirely. It is advisable to digest the gelatinised starch for a certain definite time for every mixing and in this way reduce the possibility of irregularity to a minimum.

Although the authors have given this process some prominence, it is doubtful whether it can be applied with any measure of success for sizing. There are too many chances of the starch being spoiled in the process, and it is really beyond the powers of an ordinary size mixer to get uniform results with it.

It may be well to point out that the diastase of malt has no action upon the starch in the presence of chloride of zinc, or other powerful antiseptic.

Almost all the varieties of dry soluble starch, met with by the authors, retain the original form of the starch granules, and if alteration has taken place, it is shown only by a slight fraying of the edges.

The following analysis of a sample of soluble starch will show its average composition:—

	Per cent.
Starch	79'25
Mineral Matter	0'67
Water	20'08
	<hr/>
	100'00
	<hr/>

This sample was free from glucose or dextrin.

USE OF SOLUBLE STARCH IN SIZING.

Soluble starch cannot be used to the same extent in sizing as in "finishing" cotton cloth. The reason for this is that the processes by which starch is rendered soluble destroy its adhesive powers to a very great extent. This renders it quite useless for the purpose of fixing mineral substances to the yarn, and at the same time reduces its strength-giving powers very considerably. This latter condition is a matter of little consequence in "finishing" but in a preparatory process like sizing, and one which is carried out for the purpose of rendering the yarn suitable to undergo a manufacturing process like weaving, it is a most important condition. From this it will be seen that the ordinary soluble starch of commerce is not a suitable substance to employ for sizing ordinary yarns where as much additional strength, with as small a percentage of size as possible, is required.

If soluble starch be used in sufficient quantity the requisite strength may be obtained from it, but it would be a very expensive process to use this substance for sizing yarns up to 40 or 50 per cent., when China clay can be used, in conjunction with ordinary starch, to get the same strength and percentage of size.

Soluble starch is useful for sizing strong yarns, such as two-fold yarns, where a moderate amount of additional strength only is required, and where the

size is used principally for laying the fibre of the yarn for the purpose of assisting in reducing the friction in the loom. Soluble starch is also particularly suitable for sizing yarns, such as the afore-mentioned, where a very transparent size is required.

Soluble starch may be used with advantage in very heavy sizing for the purpose of thinning down the mixing. This is probably due to the fact that commercial soluble starch generally contains a trace of free acid. This will act upon the other starch of the mixing and cause it to boil thinner than would otherwise be the case. The advantage to be gained is, that in thinning down a very thick size it is rendered less difficult to handle.

If some process for the manufacture of soluble starch could be introduced in which the adhesiveness of the original starch would be unaffected, it would be of immense advantage in sizing. Soluble starch would then possess all the advantage of ordinary starch for fixing mineral substance to the yarn, with the additional advantage of being able to penetrate the cell of the cotton fibre, as well as filling up the interstices between the fibres of which a thread is composed. This would give a full thick feel to the yarn, as well as imparting additional strength for weaving purposes.

Some three or four years ago an American firm of starch manufacturers used the statement contained

in the previous paragraph for the purpose of pushing the sale of another of the many forms of soluble starch. In this case the starch was prepared from maize by a treatment which produced an effect which gave the product the characteristics of wheaten starch. When applied to the yarn it had none of the harshness of size prepared from maize starch, but gave the mellowness of wheaten starch. The preparation was put on the market mixed with 5 per cent. of maize oil, and thus required no addition of tallow. The one objection to it was the price demanded for it. The Americans forgot that Lancashire has the whole world from which it may purchase its starch, and is not confined, like the United States of America, to its own productions ruled by "Trusts."

This firm objected to analyses of this preparation made by the writer. In an interview he was told that his certificates, stating that the starch was prepared from maize, were all wrong. He was informed that it was prepared from wheat, but that the processes to which it had been subjected in the preparation had given the starch granules the appearance of maize when examined under the microscope. The writer suggested that if they were clever enough to make wheaten starch look like maize there was a more profitable field for them if they would get out a process which would make maize look like wheat under the microscope, seeing

that at that time maize was worth about £11 per ton whilst wheaten starch was worth about £24 per ton. It was another instance of "bluff."

DEXTRIN OR BRITISH GUM.

Dextrin ($C_6H_{10}O_5$) is produced from starch by various methods :—

(1) By treating starch to a temperature varying from 210° to 280° C. or 360° to 500° Fah. This change in chemical condition is greatly facilitated, and brought about at a much lower temperature, by previously moistening the starch with dilute nitric acid, slowly drying, and finally subjecting it to a temperature from about 110° to 150° C. or 230° to 300° Fah.

(2) By boiling the starch with dilute hydrochloric acid. (Continued boiling converts the starch finally into glucose),

(3) By treating starch, which has been previously boiled with water and allowed to cool, with malt extract, or powdered malt.

The first process is largely adopted in the manufacture of commercial dextrin. This article varies in colour from a pure white to a yellowish brown; as a rule the deeper the colour the more soluble the dextrin.

Commercial white dextrin might be more properly described as soluble starch, containing as it does a large amount of this substance. When examined under the microscope it generally shows the starch granules unchanged, or with only the edges frayed.

In some samples of white dextrin, however, the granules are found to be completely broken up, thus making it impossible to detect which particular starch has been used in its manufacture. White dextrin generally gives the same iodine reaction as starch, but it is easily distinguished from starch by its characteristic properties.

The yellowish or light brown commercial dextrins are those known as British gum. They consist largely of erythro-dextrin, and their aqueous solutions give a brown colour with iodine. This reaction however, is generally obscured by the violet colour produced by the starch present.

Commercial dextrin contains foreign matter. As previously mentioned, the white dextrins contain much soluble starch, and the brown varieties contain more or less glucose. Dextrin is merely one of the intermediate products in the conversion of starch into sugar. Pure dextrin can, however, be prepared by dissolving starch in moderately strong sulphuric acid, afterwards quickly neutralising the acid with caustic soda, and precipitating the dextrin with alcohol. The dextrin obtained in this way is free from starch and sugar. Below is shown the composition of a sample of brown commercial dextrin:—

	Per cent.
Dextrin 	83·76
Glucose 	4·84
Water	11·03
Mineral Matter	0·37
	<hr/> 100·00 <hr/>

Dextrin, in the form known as British gum, is not often used in sizing yarns, although it is very largely used in the "finishing" of certain classes of cotton goods. It might be used to advantage, in conjunction with farina or sago, for the purpose of giving a full feel to the yarn in pure sizing.

APPARATINE.

Apparatine is the name of a preparation which is made by treating starch with caustic soda. It is a transparent, pasty, and powerful adhesive mass. When dried, it has the appearance of horn.

Apparatine is by no means of recent introduction. Dipierre, in 1879, published a recipe for its manufacture, and, as a matter of fact, it had been in use many years before that time. The ingredients for preparing it, viz., caustic soda solution and sulphuric acid solution, are actually being offered as patented articles in Great Britain at the present time, and the vendor claims to be the discoverer of the process. How long sizers will go on paying excessive prices for caustic soda and sulphuric acid the authors cannot say, but quote this as another instance of the foolishness of buying secret preparations. There is considerable merit in the product, when properly made, but no one has any patent rights in it. The process may be applied most successfully to maize starch. The caustic soda overcomes the harshness of the maize starch granule, and produces a nice soft size

quite equal to that obtained from farina, and without the objectionable features of either farina size or raw maize starch. *Apparatine* may be made as follows :—

Sixteen pounds of farina or maize starch should be mixed with $7\frac{1}{2}$ gallons of water. To this is added gradually, during constant stirring, 4 pounds of caustic soda solution Twaddelling about 66 degrees. In a short time the mixture gelatinises, and, at the same time becomes transparent. Prepared in this manner, *apparatine* resembles the mucilage produced by mixing gum tragacanth in water. It does not turn sour when exposed to the air, nor will it develop mildew. It is not possible to use this preparation in its strongly alkaline form for most purposes in sizing or finishing, it is therefore necessary to nearly neutralise the caustic soda with sulphuric acid, completing the neutralisation with acetic acid. For this purpose the following quantities, and the methods of procedure given may be adopted :—

Mix together in a suitable vessel 100 pounds of maize or other starch, and 40 gallons of water ; then add gradually, with constant stirring, 23 pounds of caustic soda solution at 66° Tw., and 24 gallons of water. These should be allowed to stand for at least two hours, and then 56 pounds of sulphuric acid at about 25° Tw. added. After standing, the preparation should be tested for acid or alkali

by means of litmus paper. The greatest care must be exercised in seeing that no free sulphuric acid is left in the mixture. In the proportions given above an excess of alkali will be present in the completed product. This may be neutralised with acetic acid if desired; any slight excess of this acid being removed on boiling the mixture. The proportion of water mentioned may be varied according to the requirements of the sizer.

Apparatine is sometimes prepared by *boiling* maize starch with caustic soda and water, and afterwards neutralising, or nearly neutralising, the alkali with sulphuric acid. Prepared in this way it requires less caustic soda, and consequently less sulphuric acid, in order to produce results equal to those obtained by the cold process.

In preparing *apparatine* the operator must exercise the greatest care in handling the chemicals employed. Caustic soda will destroy woollen cloth, and sulphuric acid is equally dangerous if it be allowed to dry on the fabric. Both these chemicals are likely to cause serious damage if they come in contact with the eye, and the consequence of such an accident might result in the complete loss of sight.

GUM TRAGACANTH (GUM DRAGON).

Gum tragacanth is a gummy exudation from *astragalus gummifer*, obtained by making incisions in the stem of the plant. It occurs in white or

somewhat yellowish flaky pieces of varying lengths and breadths. The pieces are thin, oblong or roundish, more or less curved, very tough, inodorous, and almost tasteless. Gum tragacanth usually contains about 60 per cent. of a substance which yields pectic acid by boiling with water containing hydrochloric acid. It also contains about 8 or 10 per cent. of soluble gum; 5 to 6 per cent. of starch and cellulose; 3 per cent. of ash; 20 per cent. of water; and traces of nitrogenous bodies. The ash is chiefly carbonate of calcium.

Gum tragacanth is insoluble in alcohol or ether, and slightly soluble only in water. In contact with much water, however, it swells up, forming a thick jelly-like mucilage. This mucilage gives the starch reaction with iodine. It is coloured yellow with caustic soda. The gum is not precipitated by borax, alkaline silicates, or ferric chloride, but it is precipitated by alcohol.

The quality of the gum may be judged to a great extent by its colour; the whiter the colour the better the sample.

Gum tragacanth is not often used in sizing, although certain manufacturers believe they get some special advantage by using it. If the matter would only be considered carefully, the authors feel certain that gum tragacanth would disappear from sizing altogether. In mixings where it is used, the amount of *actual gum* is infinitesimal,

and what possible good results can be expected from this small quantity is beyond the understanding of the authors.

Another objection to the use of gum tragacanth is its price, and when it is known that its properties can be imitated to a great extent by mixtures of starch and white dextrin, it will be seen how expensive a substance it really is.

Where gum tragacanth is used it is necessary to steep it for at least a week before mixing it with the other ingredients of the size. The mucilage ought really to be passed through a very fine sieve, in order to remove minute particles of ungelatinised gum. If this process be not carried out there is a danger of these particles of the gum sticking to the yarn, in the form of flattened discs, or else they are left adhering to the finishing roller on the tape frame. There is also a danger of these small particles of gum developing mildew, on account of not having become impregnated with the proper amount of chloride of zinc.

GUM TRAGASOL.

This is the registered name of a comparatively new material for sizing and finishing, which is manufactured by the Gum Tragasol Supply Company Limited, of Hooton, and protected by numerous patents. The gum is prepared from the kernel or

seed of the locust bean, or St. John's bread, the fruit of the carob tree, *ceratonia siliqua*.

The locust bean itself is a valuable ingredient of prepared cattle foods, but there was little use for the hard kernels until it was found that they contained a valuable gum, the extraction of which gave rise to the present industry.

These kernels are found to consist of three distinct parts:—First, a hard brown husk; second, two white cotyledons; and third, the germ, which consists of two thin yellow layers separating the two cotyledons.

The portion of the kernel used in the manufacture of the gum is the cotyledon, and in order to free it from the deleterious brown husk and yellow germ, it has to be subjected to a prolonged and specially devised milling process.

When the milling process is completed the kernels resemble small white buttons, and consist almost entirely of gum and woody fibre. The gum is extracted from the milled kernels by cooking them in steam jacketed vats, until all the gum has exuded; by this means a thick mucilage, consisting of gum and woody fibre, is obtained. This mucilage is filtered by means of hydraulic presses, and the clear gum obtained is cooled by passing over copper cylinders into jacketed vats, through which ice-cold brine is circulated. It is then mixed with a small quantity of some preservative, such as carbolic acid.

Gum Tragasol is a stiff, nearly transparent, jelly, and, previous to the addition of carbohc acid, it is practically tasteless and odourless. It is perfectly neutral, and from the following analysis, it will be seen that, although it does not contain either sugar or starch, it is almost a pure carbo-hydrate. The mucilage, dried at 212° Fah., has the following composition:—

	Per cent.
Carbon	43'51
Hydrogen	6'23
Oxygen	48'38
Nitrogen	0'39
Ash	1'49
Analysts, Messrs. Stocks and White.	<u>100'00</u>

Tragasol mixes readily with practically all the materials generally used in the preparatory finishing and sizing operations of the textile trade. It contains a large percentage of water owing to the necessity of its mode of extraction and manufacture, and were it not so, its use would be rendered more difficult owing to its being partially insoluble in water.

For most purposes, however, Tragasol requires diluting with water to prepare it for use. The best method is as follows:—In a suitable pan or mixing beck, preferably fitted with compound dashers to ensure perfect mixing, place a given quantity of the gum. This is agitated for an hour or two, until it becomes more elastic in its condition. Cold

water may now be run in, very gradually at first, until a quantity equal to the gum has been added, say 11 gallons to one cwt. of Tragasol, or of course a larger quantity according to the purpose or mixing required. During this operation the gum absorbs the water, and, if properly carried out, it is left after such dilution in a syrupy smooth condition not unlike thick oil or glycerine.

Generally speaking, the application and use of this gum lies in the same direction as the starches, but it also possesses properties peculiar to itself, and which may be utilized in attaining special effects and "finishes." For sizing, Tragasol may be looked upon as an adjunct to flours and starches, combining with them, and aiding in feeding, agglutinating, and strengthening the yarn. It is also used as a carrying agent for fixing weighting materials, such as China clay, etc.

Gum Tragasol is also used in a number of other applications which are outside the scope of the present work.

ICELAND AND IRISH MOSS (CARRAGEEN MOSS).

These substances are occasionally used in sizing. They owe their adhesive properties to the "pectin," or vegetable jelly, which forms a large proportion of the sea weed. The solution, obtained by steeping and boiling with water, is gelatinised by

the addition of acids and alkalies. "Pectin" is precipitated on the addition of alcohol. The mucilage used for sizing may be prepared from the seaweed either by macerating in hot water for twenty-four hours, and then boiling and straining, or by macerating in a solution of caustic soda, afterwards boiling and straining. The alkali is then neutralised with sulphuric acid. By this latter process a mucilage, superior in adhesive powers to the one formed by a treatment with water only, is obtained.

GLUE AND BONE SIZE.

Glue is occasionally used for the purpose of sizing yarns. As a rule, this substance is employed for sizing two-fold yarns where a perfectly transparent size is required.

Bone Size is an inferior form of glue, and it is principally employed in the fustian trade.

N.B.—Flour Milling, together with the production of farina and dextrin, from a commercial stand-point, are further dealt with in the appendix.

GLUCOSE.

Although glucose possesses adhesive powers the authors propose to discuss this substance under "softeners."

CHAPTER II.

Materials used for giving weight and body to the Size and Yarn.

CHINA CLAY, EPSOM SALTS, BARYTES,
SULPHATE OF SODA, SULPHATE
OF LIME, ETC.

CHINA CLAY—KAOLIN.

CHINA Clay is the most important of all the materials used by sizers for giving weight and feel to the yarn. It is an almost pure hydrated silicate of alumina, and is produced by the decomposition of mineral felspar, a double silicate of potash and alumina. When this mineral is exposed to the action of the air, rain, frost, and carbon dioxide of the atmosphere, it crumbles to a fine powder. The clay thus produced is found mixed with various impurities which must be removed before it is fit for use.

China clay is used for a variety of purposes, and different classes of clay are required for different industries. A clay suitable for making into pottery

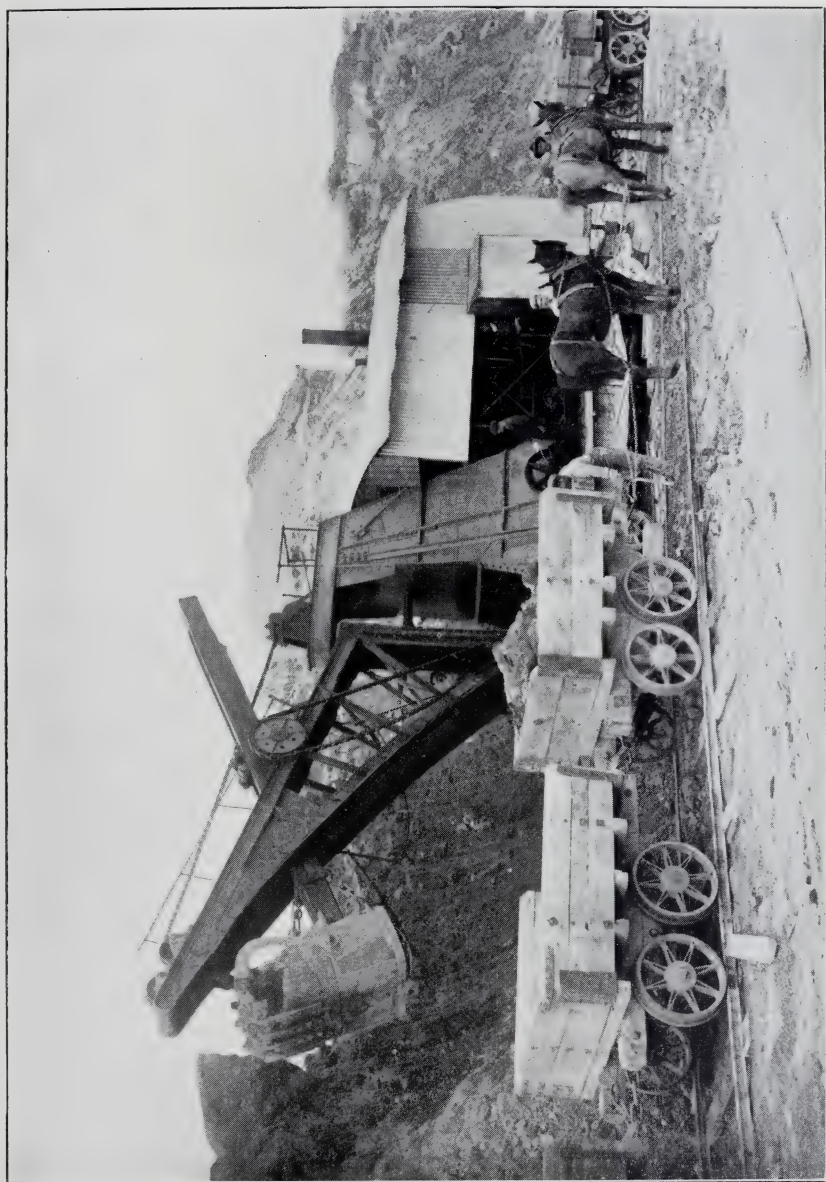


Plate II.—Removing the “Overburthen” or Surface Earth



Plate III.—General View of China Clay Mine.
The West of England China Stone & Clay Co. Ltd.

would be quite unsuitable for sizing purposes, and *vice-versa*. The reason why potters' clay is unsuitable for sizing is that it is too plastic, and would produce an unworkably thick mixing. The lower grades of clay are sold chiefly for making some classes of paper. They are similar in character to sizing clays excepting that they are not so finely washed; high grade clays are, however, used for coating paper.

Usually more than one quality of clay is got from one mine, and it is in determining the quality and suitability for one purpose or another that the expert skill of the producer, ably assisted by the foreman, or "captain" of the mine, is brought into play. These men have worked all their lives in the clay mines, and they are able to tell at once which particular portion of the clay bed being worked will produce the whitest and most suitable clay for sizing.

The following analyses show the composition of two samples of China clay of good average quality for sizing purpose :—

	No. 1 Per Cent.	No. 2 Per Cent.
Silica	46.77	45.89
Alumina	40.13	40.70
Oxide of Iron... ..	.38	.....
Lime ... ..	.....	.....
Magnesia... ..	.....	.....
Potash and Soda Salts	1.14	1.49
Water	11.58	11.92
	100.00	100.00

In this country China clay is found almost exclusively in Cornwall and Devon. The town of St. Austell is the centre of the industry in Cornwall, and about five-sixths of the total clay mined is got from this district. The Cornish clay is very white and more unctuous to the touch than that found in any other part of the world. It is largely exported to the Continent and to the United States of America.

The writer recently visited some of the largest works in Cornwall with the object of getting at first hand the details of the modern processes involved in the production of China clay. Amongst the firms who were courteous enough to permit an inspection of their mines were The West of England China Stone and Clay Co. Ltd., Great Beam Clay Co. Ltd., Hendra Clay Co. Ltd., and Carrancarrow Clay Co. Ltd.

One of the most interesting sights in the visit was seen in the opening up of a new mine. This was specially instructive as it gave an opportunity to see the processes involved in prospecting for China clay in a way that a visit to an older mine could not have given. It is only by such an experience that one is able to realise the magnitude of such a work.

The first essential is to determine whether there is a deposit of clay of sufficient area and depth to be worth working, as the cost of opening up a new mine is very great. Trial pits are first sunk into the clay bed, and if they are shown to be satisfactory

a central shaft is sunk to the bottom of the clay deposit, and another one is sunk near the outer edge of the clay area. The first shaft is called the "washing shaft," and the second one is called the "engine shaft." These shafts are connected at the bottom by means of a tunnel or "level."

The overburthen or surface earth is then removed from around the top of the "washing shaft," as shown in the illustration on *plate ii*, and carried by means of wagons, running on rails, to a refuse heap on the outskirts of the clay bed where it is deposited.

After the surface earth has been removed water is brought in to begin the operation of washing the exposed clay. Gradually the clay immediately round the "washing shaft" is taken out, and in this way the mine is being continually made deeper and wider,

The processes involved in getting the clay are better seen in a mine which has been worked for some time. The illustrations which follow will make these operations more clear to the reader than a written description alone could possibly do.

The first operation consists in breaking up a portion of the bed of clay from top to bottom by means of a "dubber" or pick. A small stream of water is then brought to the head of the "stopes" or sloping sides of the mine, by means of wooden conduits, and directed over the area of broken clay.

Workmen agitate the water against the disintegrated clay in order to assist in its removal, as shown on *plate iv*. Others are employed in breaking up the larger masses to facilitate the action of the water. The clay, together with a large quantity of gritty matter, consisting of coarse grains of quartz, mica and fine sand, is carried by the water to the bottom of the mine where it is directed into a pit called a "sand drag." Here the coarsest particles are deposited. It is usual to work two or more "sand drags," so that whilst one is being filled with the washings from the clay bed the other is being emptied of the coarse deposit by workmen. This deposit is hauled, by means of wagons running on rails, to the top of the mine, where it accumulates in huge mounds, as shown in the illustration of the Dorothy mine on *plate v*. These mounds of coarse quartz and sand are the land-marks of a China clay district, and there is a fortune awaiting the individual who can put this waste to some profitable use.

From the "sand drags" the clay water is allowed to flow down the "washing shaft," and along the tunnel previously mentioned, to the "engine shaft," through which it is pumped up to the surface of the mine by means of enormous pumps, and carried by means of an earthenware pipe to the refining floors. The refining floors, of which illustrations are shown on *plates vi, vii and viiiA*, consist of a number

of wooden troughs or channels arranged parallel to each other. These troughs are about two feet wide, and about 200 feet long.

The clay, in suspension, enters at the top end of the refining floors, and it is distributed over the area of the channels. These channels are arranged with a slight fall so that the flow of the clay water is gradual. This allows the mica and fine particles of sand to fall to the bottom of the troughs whilst the suspended clay is carried forward. A number of boards are placed along the course of the channels to assist in collecting the deposited sand and mica. These boards are called "traps," and the coarser particles settle against them whilst the finer clay in suspension passes over the obstacles when the liquid rises sufficiently high. The coarsest mica and sand settles at the place where the pipe from the works enters the refining floors, and the deposit is finer and finer as the clay water reaches the outlet of the channels to the first settling "pits." As the sediment accumulates and approaches the top of the "traps" the inward flow of the clay water from the works is suspended periodically, in order that the accumulation of deposited matter may be removed from the refining floors. This is done by removing a plug in the bed of the channels, and the mica and sand, in the form of a white mud, is discharged through pipes arranged for the purpose. The channels are then thoroughly

washed before more clay water is pumped in from the works.

The clay water, now free from sand and mica is continually flowing into the first series of "settling pits," which are arranged at the far end of the refining floors. These pits are built of stone, and they are generally circular or oval in form. As a rule they are about thirty feet in diameter and about six feet deep. At the bottom of each "pit" provision is made for letting out the deposited clay where it has settled, the clear water being run off at the top. The outlet for the clay is called a "hatch," and it is opened by means of a valve. The clear water is run away into reservoirs, from which it is led back to the works to be used over again for washing the clay.

After the clay has settled in the "pits" for a certain length of time it is run off through the "hatch" previously mentioned, and passes by means of an earthenware pipe to the final "settling tanks" (see *plate viii*), which may be located close to the works, or they may be three or four miles away. These "tanks" are contiguous to the building in which the drying operation is conducted. If the mine is near to a railway siding the drying chambers are close to the works, but if it is some considerable distance from the railway the clay is run into the final "tanks" by means of the earthenware pipe previously mentioned. This is a more economical way than

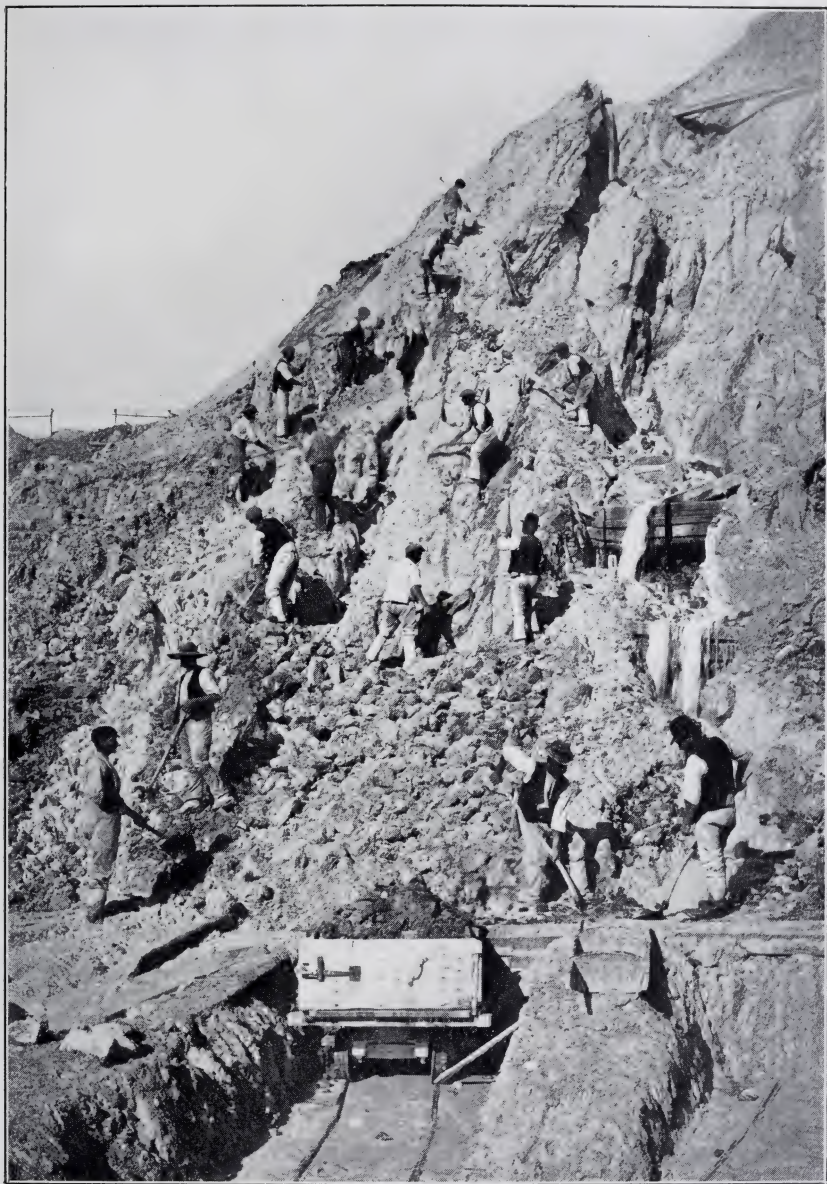


Plate IV.—Great Beam Clay Mine.
Washing Clay and showing how workmen break up the Clay ground.

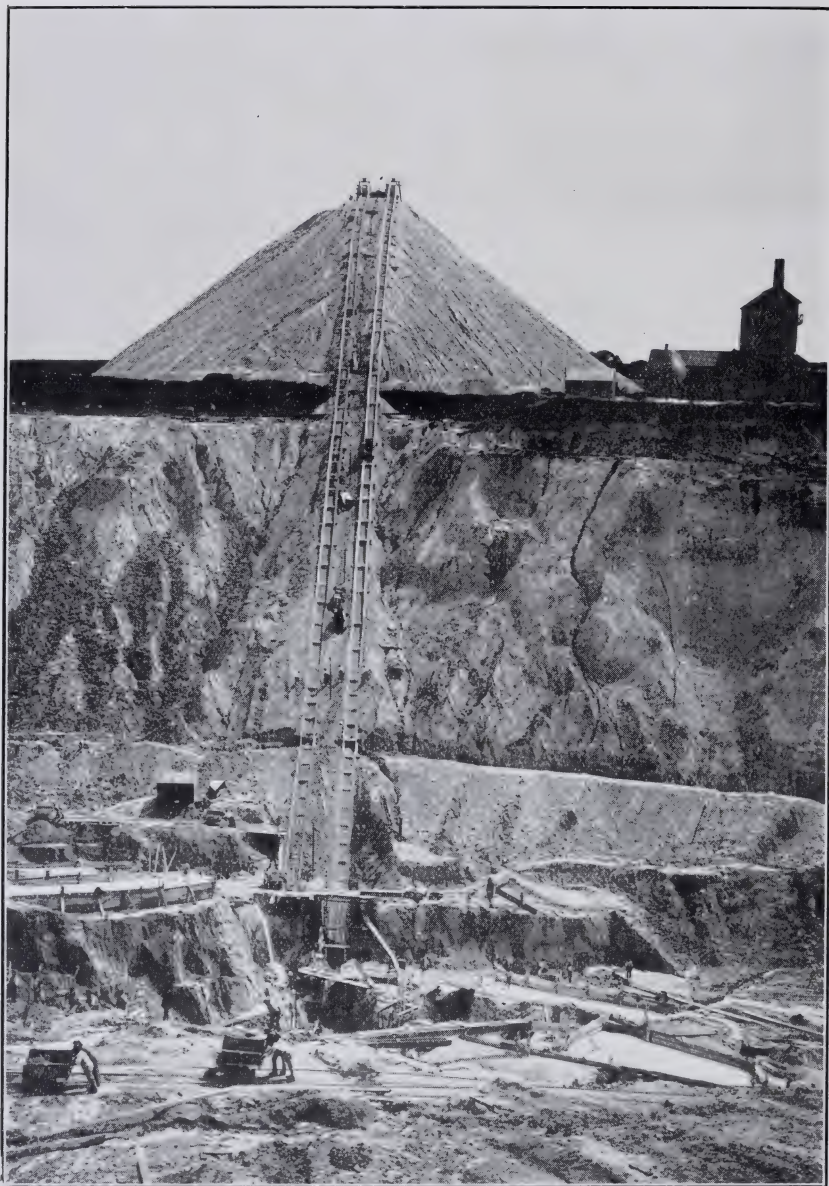


Plate V.—Dorothy Clay Mine.
Showing how refuse is removed from the “Sand Drags” and stacked.

drying the clay at the mines and carting it down to the railway. When the clay liquor reaches the final "settling tanks" it is of the consistency of thick cream, and contains about $2\frac{1}{2}$ lbs. of clay per gallon of fluid.

The final "settling tanks" are much larger than the "pits." They are usually about 150 feet long, 60 feet wide, and 8 feet deep. The clay is here allowed to settle for a period of three to six weeks, and, as the clear water gradually rises to the top, it is drawn off by means of an arrangement of plug holes in the end of the tank.

After the clay has settled sufficiently, *i.e.* about the consistency of cream cheese, it is transferred to the "dry," which is a building composed of two parts, the "dry" proper and the "linhay." The "dry" is shown in the illustration on *plate ix*, and the "linhay" on *plate x*. The floor or pan of the "dry," which is constructed of porous tiles similar in composition to fire bricks, is built on a lower level than the bottom of the settling tank in order to facilitate the tipping of the clay. The clay is brought into the drying chamber on wagons run on rails. As the wagons are brought into the building they are run on to a travelling bridge which traverses the length of the "dry," and the clay is tipped and spread over the surface of the floor to a depth of about eight or ten inches. The "dry" is heated at one end by a furnace, and the hot gases from this furnace are carried by means of flues underneath

the full length of the kiln. Combustion of the furnace gases takes place in the flues themselves through the admission of air at various points, thus spreading the heat for a considerable distance along the flues from the furnace. The drying operation takes from one to several days, the time depending upon the position of the clay in the "dry;" the portion nearest the furnace being dried the soonest. The water is separated from the clay principally by being absorbed by the heated porous tiles, and is passed as steam into the flues and stack of the furnace.

The "linhay," which is illustrated on *plate x*, is generally from six to eight feet lower than the drying chamber, and is used for storing the dried clay.

Such in brief is a description of the processes involved in the production of China clay as seen by the writer at some of the largest clay works in the world.

DETERMINATION OF THE VALUE OF CHINA CLAY FOR SIZING PURPOSES.

China clay of the best quality should always be chosen for sizing purposes. A standard sample should be kept for comparison with samples submitted for sale. This sample should be kept in a well-stoppered bottle. China clay should be tested for grit, "feel," colour, lime, iron, organic matter, and added blue.

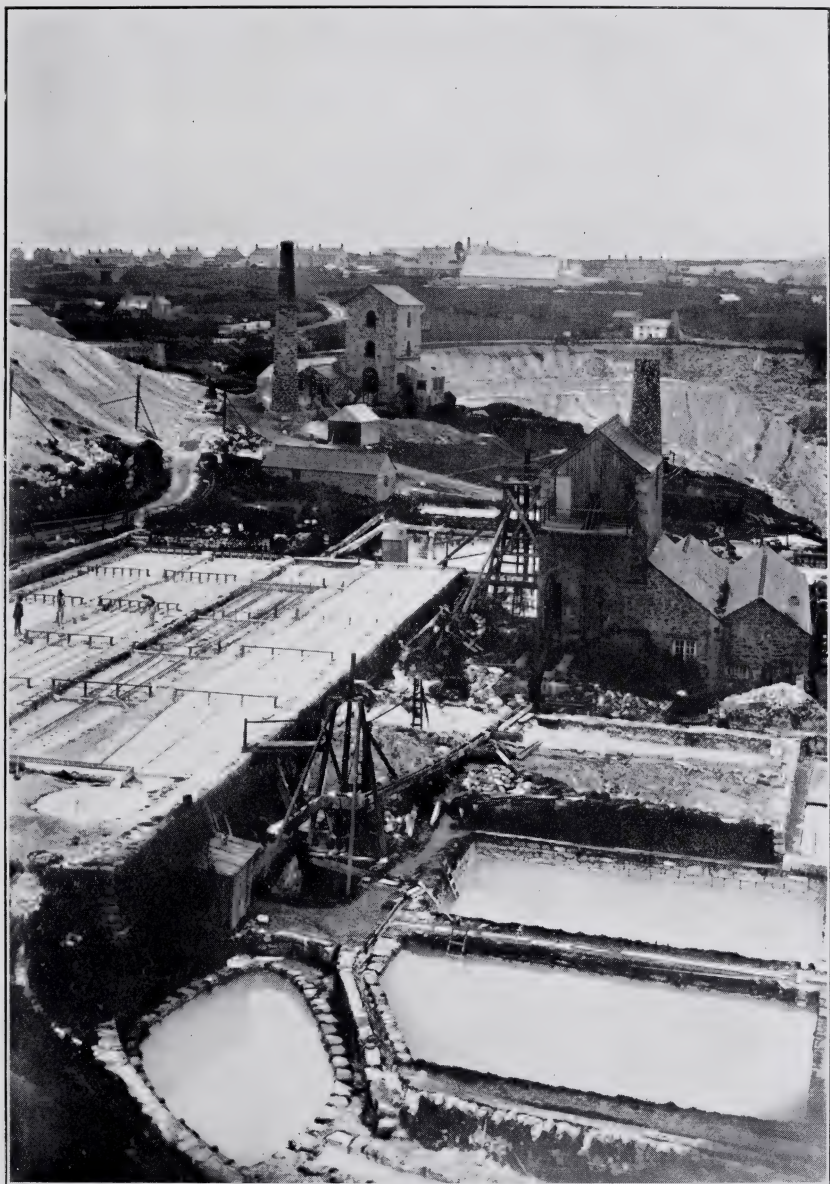


Plate VI.—General View of Trethosa Clay Mine, showing the refining floors, settling tanks, etc.



Plate VII.—Refining Floors, showing workmen clearing the deposited sand, etc., from the refining floors.

TEST FOR GRIT.—Clay may be tested roughly for the presence of this objectionable impurity by placing a little of the sample between the teeth, when any slight grittiness is at once apparent. A better test, and one that can be made comparative, is carried out as follows :—

Equal portions of the clays under examination are rubbed up into thin pastes with equal quantities of water, in separate watch glasses. A small portion of each sample is then placed on a smooth piece of glass (the glass slides used for the microscopic examination of starch are the most suitable), and a thin cover glass placed over it. The cover glass is then rubbed, with gentle pressure, on the paste, when the slightest grittiness is at once apparent. Where several samples are being examined, one may be readily compared with another. A comparison should be made with the standard sample. If the clay be of a low grade, the grit will be perceptible to the fingers, when it is rubbed up with water in a watch glass.

Grit in China clay is objectionable on account of its destructive action on the healds and reeds. As a matter of fact China clay is employed not only for the purpose of adding weight to the yarn, but also to assist in softening the size which would be very much harsher without its presence. In heavy sizing a good clay is of considerable assistance to the weaving. It can be readily seen, therefore,

how objectionable it would be to employ a gritty clay.

THE "FEEL" OF CHINA CLAY.—The "feel" of China clay is an important point to consider where this substance is intended for sizing purposes. A sample may be free from grit and yet not possess the unctuous "feel" peculiar to clay of good quality. At the same time it is necessary to use careful judgment in deciding that one particular clay is possessed of a more unctuous "feel" than another, as very often the difference in this special "feel" is entirely due to the higher percentage of water contained in one of them. That this is the case may be readily seen if a sample of clay be dried for some hours, and afterwards compared with a portion of the undried original sample. The dried portion will have lost a great amount of the "feel," but it will not have lost any of its value for sizing purposes.

If any value is to be placed upon the test for "feel," the experiment must be conducted with China clay which has been dried, and afterwards made into a thin paste with water, thus negating the effect of the extra moisture one clay may contain over that of another. For this test, therefore, equal quantities of the standard sample, and the sample under examination, should be taken after drying, and placed on smooth glass plates (large watch glasses), and equal quantities of water, sufficient to make them into thin pastes, added. Each sample

should then be rubbed with the finger, and the "feel" noted. Some clays quickly absorb water, producing a creamy paste, whilst others separate rapidly from the water with which they are mixed.

COLOUR OF CHINA CLAY.—The colour of China clay is a most important consideration in selecting this substance for sizing purposes. The sample should be compared with the standard sample, by placing a small quantity of each, side by side, on a sheet of blue paper. When pressed flat the difference in colour is immediately seen, especially at the point of contact. The test should be carried further by mixing samples of the clay with water on a white plate, and comparing the colour after they have absorbed water. The yellow tint in low grade clays may be due either to iron or to organic matter, but as a rule it is due to iron. Clays of bad natural colour are frequently blued, in order to cover the yellow tint and give the desired whiteness. When the blue fades, however, the original colour of the clay will appear. Clays so treated should be tested as follows :—

A portion of the clay should be divided into three equal parts, and each part should be placed on a watch glass, and made into a paste with water.

A few drops of strong ammonia should be added to one of the pastes. The second should be treated with a few drops of bleaching powder solution,

whilst the third should be treated with a few drops of strong hydrochloric acid. If, after these tests, the pastes remain white, the clay may be passed, but if it be rendered brown or yellow, it should be rejected. The objection to tinted clays, over and above the fact that they are not of the best quality, is that the blue colour may disappear when the cloth is exposed to light, and the dark and objectionable natural colour of the clay will then appear.

The reagents, ammonia, bleaching powder solution, and hydrochloric acid, are used for the purpose of detecting the presence of either basic or substantitave aniline blue, or ultramarine blue. Basic aniline blues are destroyed by the addition of ammonia. Bleaching powder solution, on the other hand, discharges the substantitave colour as well as the basic colour. Hydrochloric acid destroys the effect of ultramarine blue, by decomposing this compound. As a matter of fact, basic aniline blue is almost invariably used for tinting China clay, because it gives a brighter appearance to the clay than a substantitave colour, and it is easier to use than ultramarine blue. A China clay of good natural colour should be affected slightly only by either of the above tests.

It will be as well to warn manufacturers that whiteness in clay is not always an index of its suitability for sizing purposes. There are some very

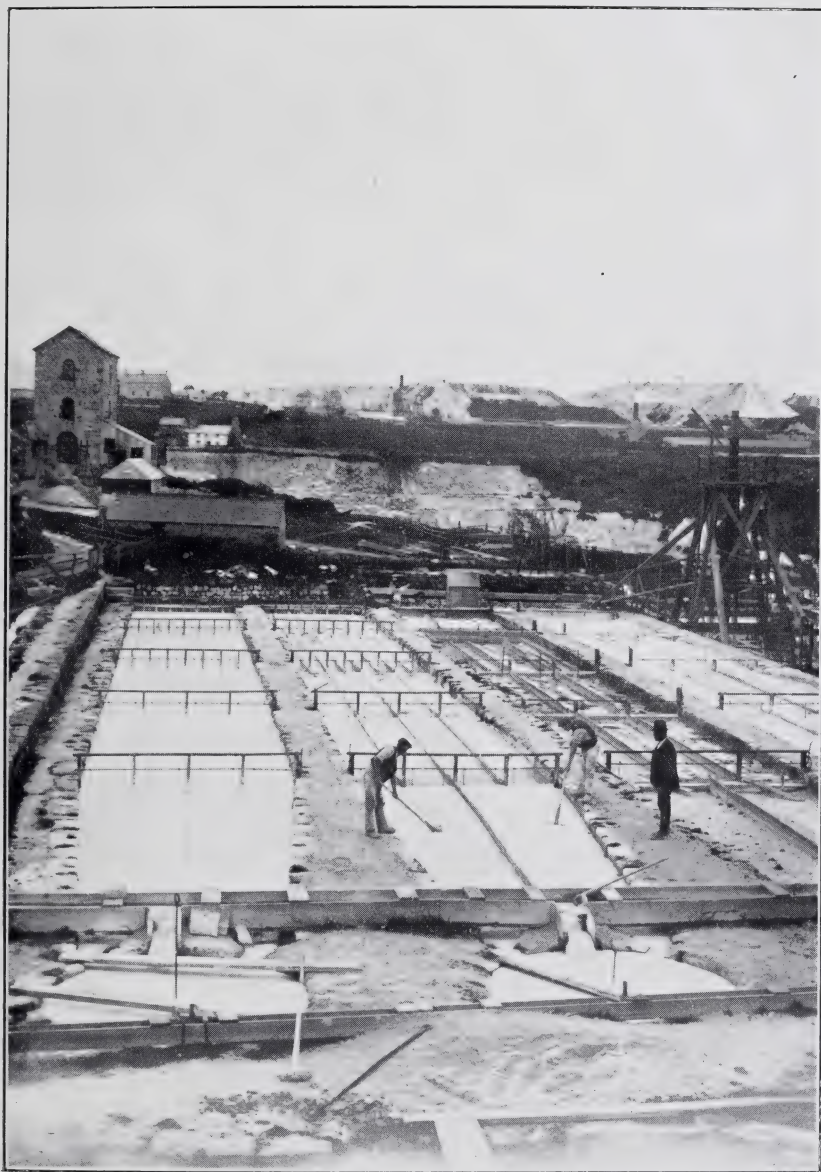


Plate VIIA.—Showing Clay Stream from mine entering refining floors.

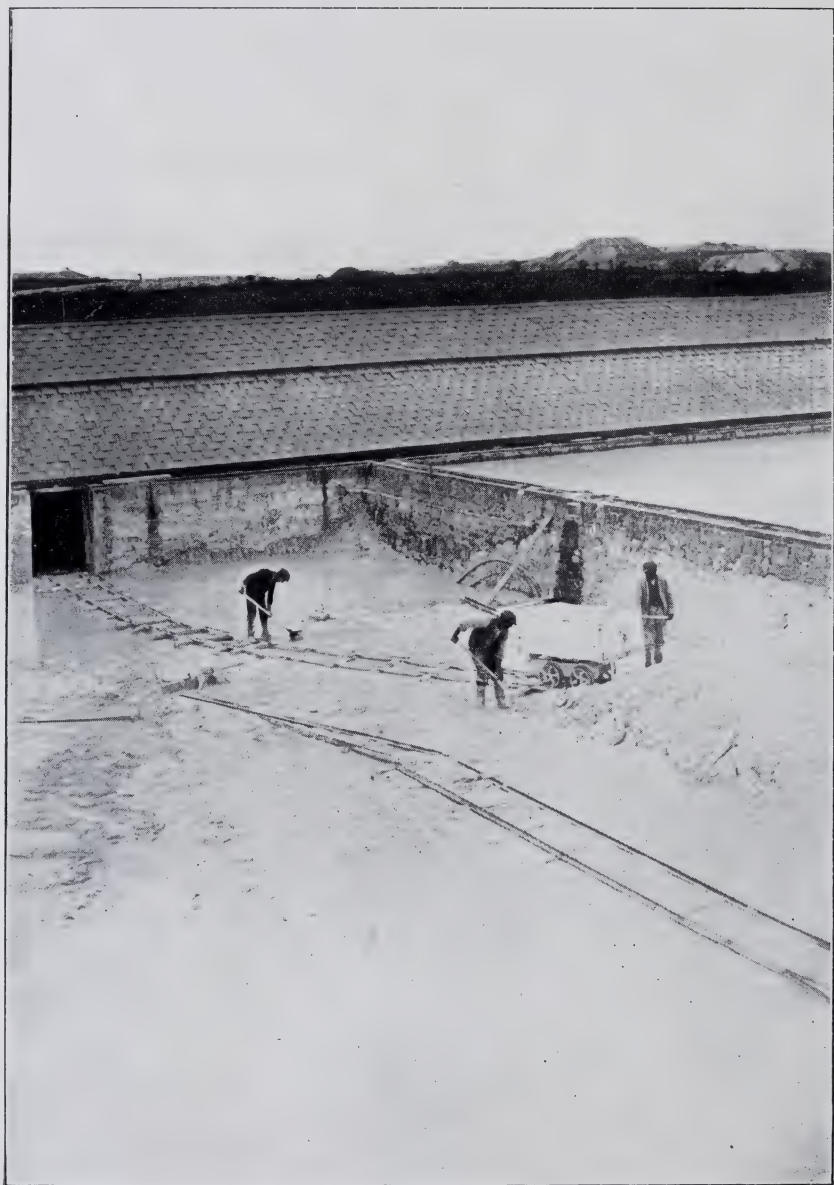


Plate VIII.—Final Settling Tanks, showing entrance to the “dry.”

white clays which are exceedingly gritty. It is necessary, therefore, to judge the value of a clay for sizing purposes by the application of other tests than that for colour only.

TEST FOR LIME.—China clay should be free from chalk or limestone (carbonate of calcium). The presence of this substance is detected by adding a small quantity of hydrochloric acid to the sample. If carbonate of calcium be present effervescence occurs, and the calcium passes into solution as CaCl_2 . The presence of calcium may be further confirmed by testing this solution in the usual way.

TEST FOR IRON.—Iron is sometimes found in China clay in sufficient quantity to damage cloth by developing iron stains. The following test should therefore be applied :—

Equal quantities of the standard clay and the sample should be mixed in separate watch glasses with sufficient water to form thin pastes. Two drops of *pure* concentrated hydrochloric acid should be added to each sample and well stirred into the mixtures. They should then be allowed to stand for five minutes, and at the end of that time, exactly two drops of a very dilute solution of ferrocyanide of potassium should be added to each. If iron be present a blue colour will be developed, varying in intensity according to the amount of iron. Most samples of China clay will give a *faint* shade of blue with this test, but in some cases the colour is very deep.

Another test, which is sometimes useful, is to mix equal quantities of the standard sample, and the clay to be examined, with equal quantities of water, and allow them to stand for several days. In clays contaminated with iron, a brownish shade is produced by this exposure. Such a sample should never be used in sizing.

ACIDS IN CHINA CLAY.—Mineral acids are occasionally employed for improving the colour of China clay. Providing every trace of acid is removed by washing there is no objection to the use of a clay so treated. At the same time the greatest care should be exercised in the selection of China clay for sizing purposes, because the presence of free mineral acid would have most objectional consequences. It would weaken the size when boiled, by converting the starch into sugar, and it would cause the reeds in the looms to rust, and so cause iron-stains on the cloth. Every consignment of Clay should be tested for the presence of mineral acids.

USE OF CHINA CLAY IN SIZING.

A good clay, especially for heavy sizing, is as important as a good flour. China clays differ so much in their physical properties that variations in sizing results may arise if a clay different from the one in general use be substituted, even when they are each of excellent quality. Some China clays give excellent

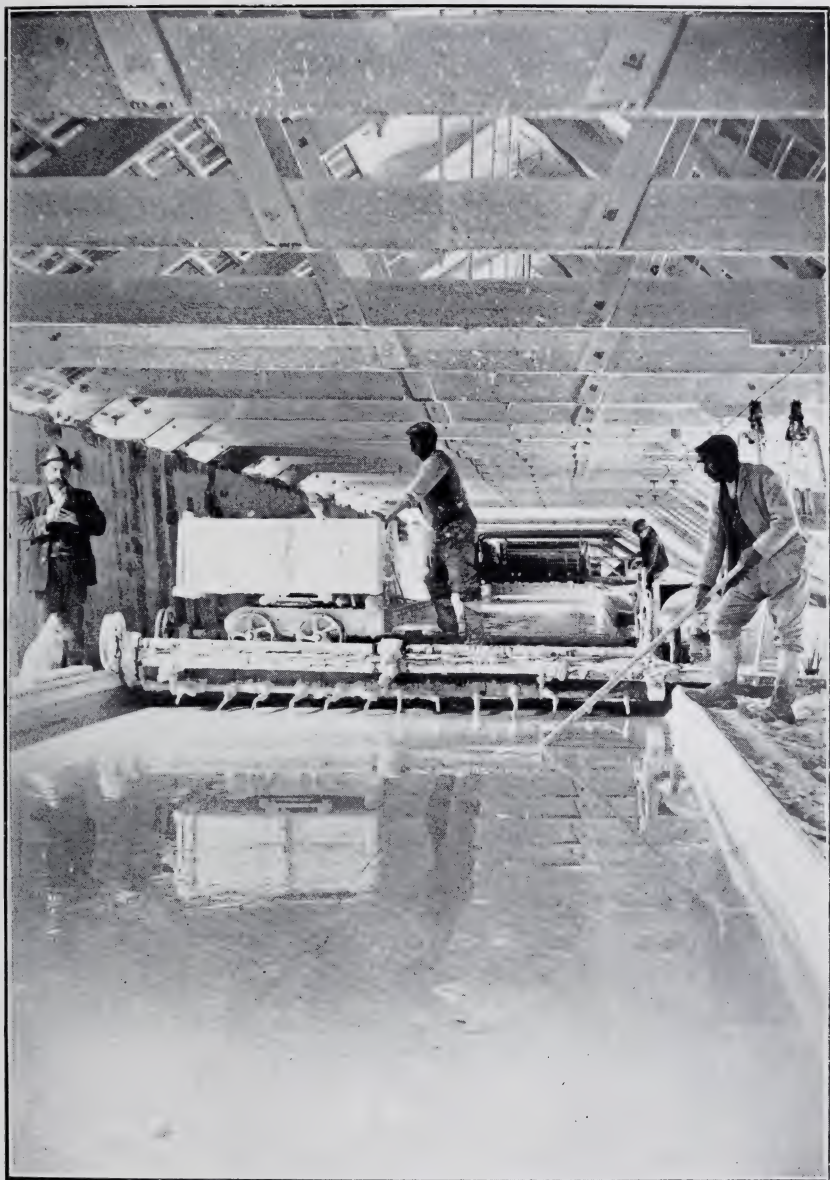


Plate IX.—The interior of the “dry” or Clay Kiln, showing electric travelling bridge.
The West of England China Stone & Clay Co. Ltd.

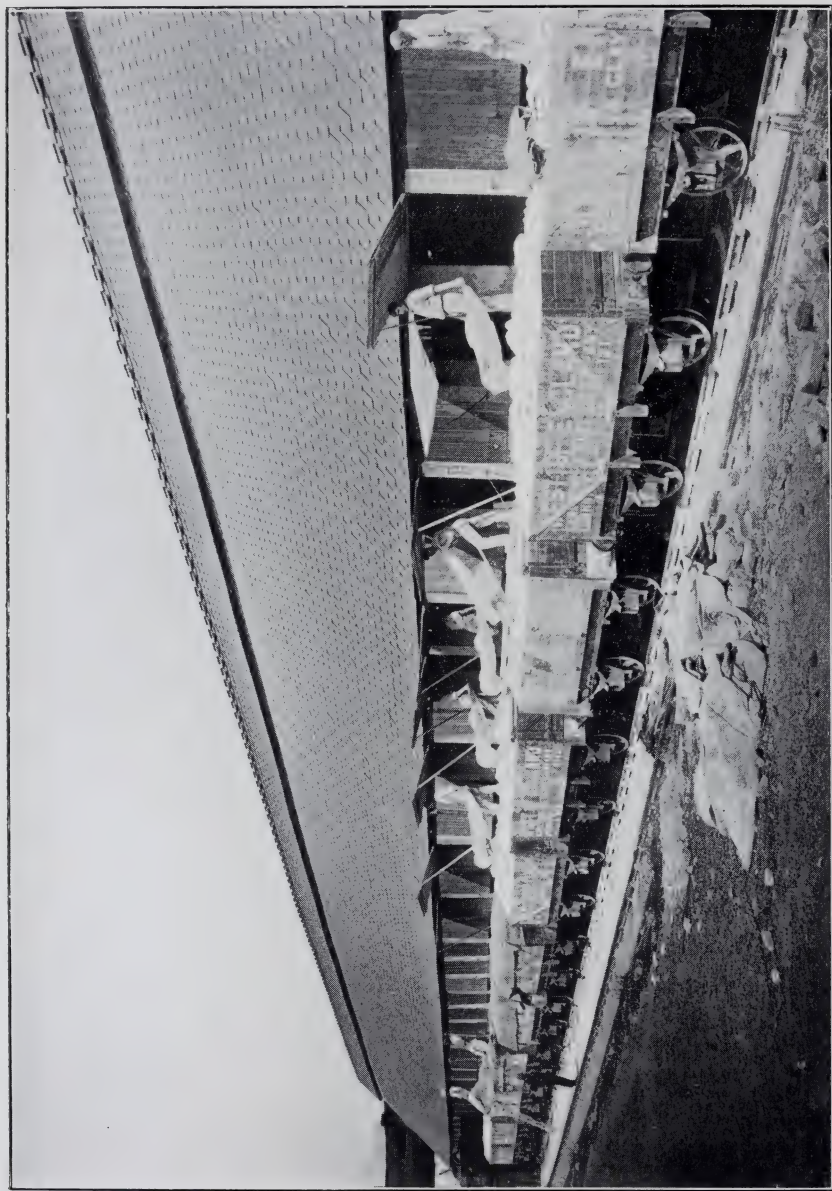


Plate X.—Loading China Clay from the “Linhay.”

results for light and medium sizing, and yet they are unsuitable for heavy sizing, owing to some peculiarity they possess which renders the yarns harsh. On the other hand, certain clays will answer equally well for light, medium, or heavy sizing. As a matter of fact, the failure to produce a well "sized" shirting is very often entirely due to the use of unsuitable China clay. The authors recommend the use of a "special superfine" clay for all classes of sizing. The difference in cost over an inferior and low priced clay is more than made up by the results. Not only are better results obtained in weaving, and in the feel and appearance of the cloth, but there is not the same wear and tear on the healds and reeds. A better looking and brighter cloth is obtained by using a high-class clay, and there is less "dusting off" in the weaving shed and warehouse.

Different samples of China clay vary very greatly also in the amount of water they require to make a heavy mixing. It is very often the case that the clay which requires the least amount of water makes the thinnest mixing. The authors have seen mixings made to put on from 150 to 160 per cent. of size vary in specific gravity as much as the equivalent of 50° Tw. There has also been a great difference in the weaving results; the thinner mixing producing a harsh-feeling brittle yarn, whilst the thicker mixing produced a smooth pliable yarn having good weaving

qualities. From this it will be seen how essential it is to have a suitable clay of good weaving properties, and one which is regular in quality. Where a mixing is given it is very necessary that the nature of the clay intended to be used should be known; otherwise the results desired may not be attained. The clay used by the authors for the mixings described in the section on practical sizing, was obtained from The West of England China Stone and Clay Co., and the quantities of the various ingredients are based upon the use of this one. The authors do not wish to suggest that there are no other suitable clays on the market, but in laying down a mixing it is necessary to have some standard as a basis, otherwise unexpected results will be obtained.

METHOD OF MIXING CHINA CLAY.

It is usual in sizing to boil China clay for periods ranging from one to six hours, the exact time depending upon the class of mixing in course of preparation.

The sole object of boiling China clay is to bring about a separation of the particles of clay as thoroughly as possible.

In light and medium sizing, where the quantity of water used is fairly large as compared with the weight of China clay, it will not be necessary to boil as long, in order to effect the separation of the clay,

as it is in heavy sizing, where these conditions are reversed.

Although boiling is looked upon as the only correct method for treating China clay, previous to its admixture with the other ingredients of the size, the authors are firmly convinced that this method is not the best one to employ. It is a different matter with starch. This substance has to be boiled in order to break up the starch granules into as fine particles as possible by gelatinisation. In China clay, however, there are no granules to gelatinise, the particles of clay being simply held together by the moisture contained therein. That this is the case is shown by drying. In the dried state it will be found to be much easier to reduce to a fine powder than in the undried state. It will also be found that the powdered clay will mix much more readily with water than clay in its unbroken state. It stands to reason, therefore, that if dry powdered clay were used, instead of damp lumpy clay, there would be no necessity for prolonged boiling with water. By way of putting this to a practical test, the following experiment was made :—

A quantity of China clay, sufficient to make several mixings, was put through a disintegrator—a machine similar to the one used for grinding the solid colours in the manufacture of paint. This operation converted the China clay into a fine powder. In this condition a portion of the

clay, sufficient for one mixing, was added to the necessary quantity of water, tallow, and chloride of magnesium. This mixture was heated, in order to melt the tallow, and afterwards mixed with the starchy matter and the chloride of zinc. This completed the mixing without requiring any boiling previous to its being pumped to the tape-frame. Treated in this way the mixing produced a better looking cloth, and the yarns sized with it wove better, than was the case with a similar mixing in which undried and unpowdered clay had been boiled for four hours in the usual way.

The remainder of the powdered China clay was used for other classes of mixings, and in every case the yarn sized with them were better, and the woven cloth was better in appearance than where ordinary China clay was used, and mixed in the usual way.

From this it will be clearly seen, therefore, that where large quantities of China clay are used, a considerable saving of time and also of steam could be effected if the clay could be bought dried and ground instead of in a lumpy condition. In the latter case steam is required for the purpose of boiling the clay for *an average* of at least three hours for each mixing. This has to be cooled sufficiently to allow the starchy matter to be added. Thus, in heavy sizing, at least six to eight hours are required to make a mixing, and steam has to be used for at least three hours. If the China clay were

purchased in a state of fine powder it would be possible to reduce the time occupied in making a heavy mixing by at least four to six hours, as well as to save at least 75 per cent. of the steam which is at present employed in boiling the clay. Not only would this be the case, but the results would be more satisfactory than under the present conditions.

The making of a mixing would be very much simplified in the case of medium sizing, where a starch like farina is employed, instead of wheaten flour. The method of procedure in this case would be as follows :—

The water, chloride of magnesium, and chloride of zinc should be put together in the mixing pan. The whole of the starchy matter should then be added, and agitated for half-an-hour, in order to ensure the separation of the starch granules. The clay and tallow should then be added, and the whole heated until the tallow melts, in which condition it readily becomes incorporated with the other ingredients of the size.

It would not be practicable to set up suitable plant for powdering China clay in every sizing establishment, but the matter is well worth the consideration of every sizer, and it would pay some China clay merchant to take the matter up. The authors are certain that the pioneer in this movement would be amply recompensed by his

increased sales as soon as the advantages of using powdered China clay became known.

EPSOM SALTS—SULPHATE OF MAGNESIUM.

This substance is prepared chiefly from kieserite, a mineral found as a natural deposit at Stassfurt, in Prussia.

Kieserite is composed of a mixture of sulphate of potash, soda, and magnesia. It is chiefly worked for its potash salt, which is by far the most valuable constituent.

Epsom salts occur generally in the form of needle-shaped crystals. These crystals contain more than half their weight of water, as shown by the following formula $\text{MgSO}_4, 7\text{H}_2\text{O}$. The proportion of actual sulphate of magnesia to water, is 12 of the former to 12.6 of the latter.

Epsom salts are used very largely as a weighting ingredient for sizing yarns in certain districts, particularly in "ball sizing." This substance is also extensively used in "finishing," for such goods as flannelettes, Oxford and Harvard shirtings, shoe linings, etc.

For "finishing" purposes it is essential that the Epsom salts be free from chloride of magnesium, otherwise there is a risk of damage occurring. The presence of chloride of magnesium is of no

consequence where the salts are used for sizing, as chloride of magnesium is invariably an ingredient of the size, and a little more or less would make no material difference in the results. The authors mention this fact because it has been stated so often that a trace of chloride of magnesium is dangerous in Epsom salts used for sizing purposes.

W. Thomson, in his book on sizing, published in 1879, and which was for many years the only valuable manual on the subject, describes a case of damage to Oxford shirtings. This matter is of considerable interest, and the authors quote the case as stated.

“A certain firm shipped Oxford shirtings, the same in quality, and made at the same time, but finished by three different finishers. These pieces were packed indiscriminately in bales, and a number of them were returned, some damaged and others undamaged. The only difference between the damaged and undamaged pieces from a physical examination was that the former were tender and the latter were not, the colour being uninjured. Had the injury been caused either by free acid or mildew, some of the colours would have been injured; but as a matter of fact, the damaged pieces were practically free from acid, and no trace of fungus growths could be found. A most marked difference, however, was shown by chemical analysis. Each contained chloride as well as sulphate of magnesium, but all

the damaged pieces contained a much larger quantity of the chloride than the undamaged. The following gives the ratio of chloride of magnesium to sulphate per centum in each sample:—

	Damaged.	Undamaged.
Crystallized Sulphate of Magnesium ...	86·8.....	98·11
„ Chloride of „ ...	13·2	1·89
	<u>100·00</u>	<u>100·00</u>

It seemed then that chloride of magnesium was capable of tendering cloth by reason of some physical action; and various experiments were made with a view of testing this point. It is well known that if a piece of cloth be steeped in a solution of sulphate of magnesia, taken out, and the salt allowed to crystallize in the fabric, the latter will be more or less slightly tendered; and if the salt be washed out, and the cloth again dipped into the solution, and the salt allowed to crystallize in it, the cloth will be still further tendered; and if this be done repeatedly the cloth would become as weak as tinder.

The question then suggested itself whether chloride of magnesium might not produce a very similar effect, and by experiment it was found that it would do so. The chloride being a very deliquescent salt, would, especially in damp weather, remain in the fabric as a liquid, and as such would dissolve some of the Epsom salts; but if the weather became colder or drier, or both, the “salts” alone, or in

company with the chloride of magnesium, would crystallize in the fibre, and in so doing would expand in the filaments of cotton and rupture them.

This action of crystallization and solution, so far as the heat and cold are concerned, can be observed in the storm glass, where in cold weather the glass seems nearly full of crystals, whilst in warm weather only a few can be observed at the bottom of the liquid. The damage above-mentioned was therefore clearly traced to this peculiar action. It is questionable, however, whether this action could take place *except* where the goods were heavily weighted with sulphate of magnesium, and contained a *considerable percentage of the chloride.*"

In quoting the above, the authors do so for several reasons. The question of danger from the use of Epsom salts in conjunction with chloride of magnesium is one which is frequently brought forward, and whilst we agree with the conclusion in the particular case of Oxford shirtings quoted, we do not agree with the statement that "this action could only take place where the goods were heavily weighted with Epsom salts, and contained a considerable percentage of the chloride." Practical experience points to the opposite, and shows that where a large proportion of chloride of magnesium is present, sulphate of magnesium does not tender the cloth. It is common knowledge that large quantities of Epsom salts are used regularly in conjunction with chloride of

magnesium in sizing, and no damage has ever been known to occur. The following mixing has been used for many years without tendering taking place, and it is only one of many known to the authors:—

Flour.....	6 $\frac{1}{4}$ bags (280lb. per bag).
China Clay	5 $\frac{1}{2}$ bags (224lb. per bag).
Tallow	324 lb.
Epsom Salts.....	5 cwt.
Chloride of Magnesium	54 gallons at 60°T.
Chloride of Zinc.....	25 gallons at 102°T.

It will be seen, therefore, that, notwithstanding the statement of Mr. Thomson referred to on page 157, so large a relative proportion as 30 per cent. of chloride of magnesium to 70 per cent. of Epsom salts may be used without ill effects resulting.

In the opinion of the authors the danger from the chloride of magnesium is when it is present only in small quantities as an impurity in the Epsom salts used in “finishing,” but never when it is used in large quantities in sizing, especially where there is also present a large quantity of such a powerful deliquescent substance as chloride of zinc.

The damage, produced in the case quoted, was probably due to the *small* proportion of chloride of magnesium present. This would allow the Epsom salts to crystallize under certain atmospheric conditions, and re-dissolve under others, whereas in sizing, where a large proportion of chloride of magnesium is present, the yarns are kept in a moist condition (a condition not desired in “finished” goods).

In spite of the theory of the cause of damage in the above-mentioned case, it is a matter of fact, that large quantities of flannelettes, shoe linings, etc., are "finished" with Epsom salts in conjunction with chloride of magnesium and glucose, and the authors have never come across a case of damage which could be attributed to this cause. The chief risk from the presence of chloride of magnesium in "finished" goods is, that during the drying process, the chloride of magnesium may be decomposed with the formation of free hydrochloric acid. This would tender the fabric. There is more danger of damage from this cause in "finishing," than there is in sizing. The reason for this is two-fold. In the first place, "finished" goods have, as a rule, been bleached, and this renders them more susceptible to the action of free acid than grey yarn which has not lost its protective coating of waxy and oily substances. In the second place, the drying operations in "finishing" are very different to the drying operations in sizing. In the former case, the cloth passes over a large number of drying cylinders, whereas in the latter case the yarn passes over not more than two. The effect of drying by means of a large number of heated cylinders is more severe than where the yarn passes over two only, as the first three or four cylinders practically remove the excess of moisture, and the remainder are employed in heating an almost dry fabric. This is not the case

when yarns are dried on the tape frame ; the object of the taper being to remove the excess of moisture only, and not to over-dry the yarns. It will be readily seen from this, therefore, that although there is danger of damage from the presence of chloride of magnesium, by over-drying in "finishing," there is no danger where the drying operation is conducted with the object of removing the excess of moisture only.

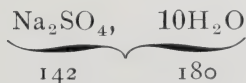
Nearly all Epsom salts contain a small quantity of chloride of magnesium. It may be detected by dissolving a little of the salt in water, and adding a few drops of nitric acid and a few drops of a solution of nitrate of silver. The quantity of white curdy precipitate which forms is a rough indication of the amount of chloride present. Comparative tests may be made by keeping as a standard the sample which shows the least precipitate, and changing the standard when a better one is obtained. Care should be taken to use the same quantity of Epsom salts in each case, and for this purpose a small measure should be kept, or a definite weight should be dissolved in a definite measure of water, and the same quantity of nitrate of silver solution used for each test. Students who possess the necessary knowledge will of course test for the amount of chloride of magnesium in the usual way.

Epsom salts is a good filling material. It is very soluble in water, and in consequence it is readily

absorbed by the fibre, thus giving the fabric a substantial feel. It is not an ideal substance to use in conjunction with starch, however, as it gives rise to dusty mixings. This condition is brought about by the action of the Epsom salts on the starch which it tends to precipitate.

SULPHATE OF SODA— GLAUBER'S SALTS.

This substance is manufactured on a large scale by adding sulphuric acid to common salt in the process of preparing soda ash. Sulphate of soda is also a bye-product in the preparation of nitric acid from sulphuric acid and nitrate of soda. The sulphate of soda is left in the retort as a residue, and it is dissolved out with hot water. The acid is afterwards neutralised with soda ash, and the solution concentrated, cooled, and allowed to crystallize. These crystals, like Epsom salts, contain a large percentage of water of crystallization, more than half their weight being water, as the following formula will show :—



The crystals exist as four-sided prisms. They readily give up their water on exposure to the atmosphere, finally crumbling to a powder.

Sulphate of soda should not be used in conjunction with chloride of calcium in sizing, unless

the production of sulphate of calcium be desired. A double decomposition takes place when these two substances are brought together in solution, and sulphate of calcium is precipitated. If the chloride of calcium is being used for its deliquescent properties they would be lost, and the substances entirely changed in their character. Chloride of magnesium should always be used as a deliquescent when sulphate of soda or Epsom salts are ingredients of the size.

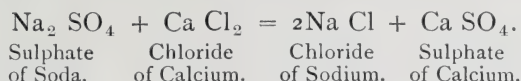
SULPHATE OF CALCIUM-- SULPHATE OF LIME.

This substance is also known as Gypsum, the dehydrated form of which is plaster of Paris.

Sulphate of calcium has been used to some extent as an ingredient of size, but the harsh feel which it imparts to the cloth is against its general use.

A mixture, containing precipitated sulphate of calcium, chloride of calcium, and chloride of sodium, has been largely sold as a combination for producing good weaving, and for producing a "boardy feel" in the cloth. Mixtures of this description are prepared by mixing together strong solutions of sulphate of soda (Glauber's salts), and chloride of calcium. On admixture a chemical change takes place; the calcium is precipitated as sulphate of calcium, and chloride of sodium is produced at the same time. As

a rule an excess of chloride of calcium is used, in which case the whole of this substance is not entirely decomposed, thus leaving a portion of it in the mixture as chloride of calcium. The following equation shows the chemical change which takes place if the substances are used in exact proportions :—



Any merit this mixture may possess for producing good weaving is due to the excess of chloride of calcium, which has the power of absorbing moisture. It is therefore a round-about way of using chloride of calcium instead of adding this substance directly to the size. As a matter of fact the use of such a mixture is only making the size more complicated without obtaining any improved results.

SULPHATE OF BARIUM.

BARYTES.—MINERAL WHITE.

This substance, also known as heavy spar, has been used as a weighting ingredient in sizing on account of its high specific gravity. It is not a suitable substance to use, as it makes the yarns very harsh, thus causing the healds and reeds to rapidly wear out by friction. Sulphate of barium may be employed with advantage in “finishing” cotton goods, because there is not the same liability to

cause damage in "finishing," as there is where it is used in a preparatory process like sizing.

FRENCH CHALK.—SILICATE OF MAGNESIA.—SOAPSTONE.—STEATITE.—French Chalk, which is known in commerce under all the above names, is used occasionally in this country for sizing purposes instead of China clay, but it is not as suitable a weighting material as the latter. French chalk consists mainly of silicate of magnesia, and it is not altogether free from colour. There is a peculiar feature about this substance which makes it less suitable for sizing than China Clay, apart from its colour, and that is the difficulty of mixing it with the other ingredients of the size. French chalk has a tendency to float.

In some countries French chalk is largely used for weighting in place of China clay, especially in India. This is not due to any special merit in the chalk but to the fact that they have it on the spot, and thus save the heavy cost of carriage on China clay from England. This applies specially to "up country" mills.

SILICATE OF SODA.—SOLUBLE GLASS.—CHLORIDE OF BARIUM.—These substances have all been used for sizing, but not with any success.

CHAPTER III.

*Ingredients used to Soften the Size
and Yarn.*

FATS, OILS, AND WAXES.

TALLOW.—This substance consists essentially of the glycerides of stearic, palmitic, and oleic acids. When distilled with superheated steam tallow yields the above-mentioned acids and glycerine. Tallow is commercially known as beef or mutton tallow. In England the two are generally mixed. Mutton tallow is whiter and harder than beef tallow.

Tallow is the substance which is most subjected to adulteration. The reason for this is not far to seek. Tallow is the most expensive ingredient used in sizing, and it therefore gives the biggest margin of profit if the adulteration can be carried out without exposure. It is in the interests of all honest

dealers in tallow, therefore, that such practices should be exposed, as a dishonest dealer may be able, with very little skill, to supply so-called tallow below the market price of pure tallow, and make a very considerable profit thereby. It is within the personal knowledge of the writer that adulterated tallow is being sold every day; the dealer trusting to the ignorance of the buyer to prevent the fact becoming known. So outrageously is the deception carried on that the adulterated tallow is often actually sold with a written guarantee of its purity, in spite of the absolute knowledge of the sellers to the contrary. Their safety lies in the fact that sizers and manufacturers very rarely have the tallow they use systematically analysed, and so the dishonest dealer escapes detection. It is useless to expect the analyst to be able to detect adulterated tallow after it has been mixed with the size, and the size put on the yarn, and the latter woven into cloth, and possibly afterwards bleached, dyed, or printed. This is the reason why, in many cases of damage to cloth, the cause cannot be definitely ascertained, although it may be more than suspected. Manufacturers pay very dearly for the use of adulterated tallow. In the first place, they pay for something which they do not get, and in the second place, they are continually paying for damages which have been developed in the cloth after it has left the weaving shed.

The substances used for adulterating tallow may be classified as follows :—

(1) Fatty substances which lower the commercial value of the tallow.

(2) Substances not fat, which reduce the softening effects peculiar to fat.

(3) Substances which are actually injurious to the cloth.

The substances mentioned under the first heading include bone and marrow fats, cotton seed oil, cotton seed oil stearine, soap, and water. They are in no way injurious to the cloth, and with the exception of soap and water, have softening properties nearly equal to pure tallow.

The substances mentioned under the second heading include starch, common salt, and, in a lesser degree, the chlorides of calcium and magnesium. They are mixed with tallow for the sole object of increasing the profits of the dealer.

The chlorides of calcium and magnesium may cause damage to the cloth if it be subjected to the singeing process previous to bleaching.

The substances mentioned under the third heading include paraffin wax, mineral oil, and recovered Yorkshire grease. These substances may cause serious damage if used for sizing yarns intended for cloth which has to be bleached, but if the cloth is intended to be sold and used in the grey state and not bleached, there is not the same liability

to cause damage, unless the mineral oil is present in sufficient quantity to cause the cloth to show oil stains after it is packed and pressed.

Putting the question of damage on one side altogether it is necessary that the practice of adulterating tallow with mineral oils, which have a low vaporising point, should be strongly condemned. If tallow of this description be boiled for any length of time with the clay, a portion of the mineral oil is converted into vapour, and this is carried off with the steam and lost. This conversion from an oil to a vapour is repeated in the sow box of the tape frame, and manufacturers, using tallows adulterated in this manner, are paying for a substance the greater portion of which is driven off into the atmosphere instead of forming a portion of the size on the warp.

The objection to the presence of paraffin wax, mineral oil, and recovered Yorkshire grease, in tallow used in sizing goods which have to be bleached, and possibly dyed or printed afterwards, is as follows:— In the first place it is almost impossible to remove paraffin wax or mineral oil in the bleaching operations, and therefore, when the cloth is finished, these substances may give rise to stains in white goods. In the second place, if the cloth has to be printed or dyed, the dye will not be absorbed equally, and will thus give rise to stains of a serious nature. This matter is further dealt with under paraffin wax, and in the chapters on stains,

and bleaching. Recovered Yorkshire grease, on account of the amount of unsaponifiable matter it generally contains, is not easily removed during the bleaching operations, and it may give rise to similar damage to that produced by paraffin wax and mineral oil.

A gross case of adulterated tallow came under the writer's notice a few years ago. It was submitted for analysis with the questions:—"Is this pure tallow? If not, what proportion of tallow is there in it?" The writer reported as follows:—"The sample is not pure tallow. It contains 79.58 per cent. of tallow, and the remainder is made up of starch, common salt, chloride of magnesium, and water." The amount of the sample submitted for analysis was not sufficient to make a quantitative analysis of the different adulterants found. This case is one of the most flagrant cases of adulteration the author has met with.

More recently a firm of manufacturers decided to have their sizing arrangements inspected and reported upon. The ingredients used for making their size were submitted to the writer for analysis. The tallow, which had been obtained from one firm for many years under a guarantee of purity, was found to be adulterated with Yorkshire grease and cotton seed oil stearine. The result of the writer's report was the refunding of a sum of *Fifty Pounds* as compensation for previous deliveries, a sum of

money which paid for the writer's services many times over.

EXAMINATION OF COMMERCIAL TALLOW.—From what has been said it will be readily seen how necessary it is that all samples of tallow should be carefully and regularly analysed.

The following is a list of the more important adulterants which have been found in tallow by the writer :—

Water.

Mineral Oil and Paraffin Wax.

Bone and Marrow Fat.

Cotton Seed Oil.

“Stearine” or Stearic Acid from Cotton Seed Oil.

Recovered Yorkshire Grease.

Starch.

Chloride of Sodium—Common Salt.

The Chlorides of Magnesium and Calcium.

Other mineral matters, such as Chalk,
Barytes, etc.

The following tests should be applied before accepting a consignment of tallow for use :—

VAPORISING POINT.—This is one of the most important tests which can be applied to tallow, giving as it does many valuable indications of the purity, or otherwise, of the sample under examination. The test is conducted as follows.—About two ounces of the tallow should be melted in an evaporating basin. For this purpose the basin

should be placed on a sand-bath, the latter being heated by means of a Bunsen's flame. As soon as the tallow melts two samples should be collected for the purpose of determining the melting point. This is done by dipping the ends of two capillary tubes, such as are used for the purpose of storing vaccine lymph, into the melted fat. These should be laid on one side for twelve hours before taking the melting point.

A thermometer, registering not less than 360° Fah., should now be suspended in the melted tallow, in such a way that the bulb is entirely covered with the fat. This thermometer may also be used as a stirring rod. The heating is continued, and the first point to be noticed is the presence or absence of water. If the tallow melts without crackling, water is absent. Sometimes a little crackling occurs, at other times the fat will spurt out of the basin if not carefully stirred. In the latter case it shows the presence of a large excess of water, and the amount should be determined as described later.

The melted fat will now be at a temperature about that of boiling water, and if water be absent, the point at which the tallow gives off vapour must be carefully noticed. If water be present it must be removed previous to determining the vaporising point. This is done by heating the tallow to about 212 degrees Fah., and constantly stirring until no

more globules of water can be seen, and crackling ceases.

Pure tallow, in the winter months, vaporises at from 260° Fah. to 320° Fah., according to the quality of the fats; the higher the vaporising point, the better the tallow. In the summer months the vaporising point is considerably lowered, due probably to the different class of food eaten by the animals, but it should never vaporise below 240° Fah.

The value of the test consists in the certain detection of the following adulterants.

(1) *Water*, which is shown by the crackling produced.

(2) *Mineral Oil*, which vaporises at a temperature of from 180° to 230° Fah., according as a light or heavy oil has been used as the adulterant. The vaporising point of these oils is generally between 180° and 230° Fah.; *i.e.*, sufficiently low to give an absolutely certain indication of their presence. The characteristic smell of hot mineral oil should be looked for also.

(3) *Starchy Matter*, which will be found to aggregate in sticky particles at the bottom of the basin, due to its conversion into dextrin by the heat applied.

(4) A low vaporising point also indicates one or other of the following possible adulterants:— soap (which is always accompanied by water),

stearic acid, bone fat, marrow fat, and Yorkshire grease.

When soap is present a certain amount of frothing takes place, whilst when stearic acid is present the characteristic smell of this substance is rendered apparent. Bone and marrow fats lower the vaporising point and melting the point of the sample.

It will, therefore, be seen that if a sample of tallow be found to have a vaporising point of over 260° Fah., and does not show the presence of water or starch, and there is no smell of stearic acid, and no bone fat (the test for which is described later), it may be safely passed as pure tallow, and such tests as the "saponification equivalent," and the iodine value omitted.

FLASH POINT DETERMINATION (open test).—The vaporising point test may be carried a step further and the flash point taken as follows:—After noting the vaporising point the heating should be continued, the thermometer being previously changed for one registering about 600° Fah. A blow-pipe should be connected to a gas supply by means of a piece of rubber tubing. The flow of gas is regulated so as to get a flame about the size of a pea. The test is made by bringing this flame almost, but not quite, in contact with the surface of the heated tallow. This should be done at intervals of a few seconds. At a certain temperature the vapour will inflame; a blue flame

shooting across the surface of the tallow. This is the flash point, the temperature of which should be noted. Pure tallow should not flash below 500° Fah., but if mineral oil be present it will flash at the same temperature at which the oil would flash if not mixed with tallow. The mineral oils, with which it is possible to adulterate tallow, flash at temperatures varying from 340° to 380° Fah.

MELTING POINT OF TALLOW.—This most valuable test should always be applied to tallow. The method of procedure is as follows:—One of the samples, collected in the capillary tubes as described on page 171, is fastened to a thermometer by means of an elastic band, in such a way that the column of tallow is on a level with the bulb of the thermometer. The thermometer is fixed in a stand and immersed in cold water contained in a beaker. This beaker is placed inside a second larger beaker, containing water, in such a way that the inner beaker floats surrounded by water. The arrangement of beakers is placed on a tripod stand covered with copper gauze, and heat applied to the outer beaker by means of a Bunsen's flame. The heat should be applied gradually, the temperature not increasing more than 5° per minute. The eye should be fixed on the column of fat, and when the temperature is about 105° , the Bunsen's burner should be removed, and the outer jacket of

water, which is hotter than the water in the inner beaker, allowed to continue the heating. By this method there is less chance of error in taking the melting point than where a flame is applied directly to the beaker containing the thermometer. At the moment of melting, the column of tallow will suddenly rise in the tube, and this point should be taken as the melting point. It is necessary that the capillary tube should be long enough to leave the upper part well out of the water. If water should get in at the top of the tube, it would prevent the tallow rising easily, and the melting point would not be determined so accurately. Working in this way, the authors find that good tallow has a melting point of from 110 to 118° Fah.

A tallow having a high melting point is rarely an adulterated one. Mineral oil, cotton seed oil, or bone fat, more especially the former, reduces the melting point considerably. The authors always look with suspicion upon a tallow which melts below 108° Fah.

After taking the vaporising point, flash point, and melting point, the tallow may be further examined as follows:—

DETECTION OF BONE AND MARROW FATS.—Bone and marrow fats are always contaminated with a very small quantity of phosphate of calcium, and, unless this substance has been removed by the producer previous to placing it on the market, its presence in

a sample of tallow is a certain indication of the presence of bone or marrow fat, as phosphate of calcium is never found in pure beef or mutton tallow. It is seldom removed, as the process of purification is expensive, and it would bring the price of the adulterated tallow up to about that of pure beef or mutton tallow.

The following method of procedure should be adopted in testing for bone and marrow fats:—About two ounces of the tallow should be boiled in water containing a few drops of strong hydrochloric acid. The whole should be well stirred and then allowed to cool. When the cake of fat has set hard, the acid solution is filtered off, and tested for the presence of phosphoric acid (phosphate of calcium) as follows:—The filtrate is carefully neutralised by means of solution of ammonia. An excess of nitric acid is then added and afterwards an excess of a solution of molybdate of ammonium. A yellow precipitate is produced if phosphates be present, and this is certain evidence of the presence of bone or marrow fat.

The presence of bone and marrow fat in tallow can be recognised by the expert, even if the phosphate of calcium has been removed. Marrow fat gives a characteristic granular appearance to the tallow, whilst bone fat gives it a pasty appearance.

TEST FOR STARCH AND FREE ACID.—Starch, as previously mentioned, is occasionally found as an

adulterant in tallow, and nearly always in conjunction with water. Acids, on the other hand, may be due to the presence of free fatty acids (rancid fats), or to sulphuric or hydrochloric acids. The latter acids are sometimes used in the preparation and bleaching of the tallow. The method to be adopted for testing for these various substances is as follows:—About two ounces of the tallow should be boiled with pure water in an evaporating basin. The mixture should be well stirred and allowed to cool. When the cake of fat has set hard, the liquid is poured off, filtered, and divided into two unequal portions.

(1) STARCH.—The smaller portion is tested for starch by adding a few drops of a solution of iodine; a blue colour is produced if starch be present.

(2) ACIDS.—The larger portion of the liquid is tested for acids, first, by means of blue litmus paper, which will show the presence of both organic and mineral acids, and second, by means of methyl orange paper, which will show whether mineral acid is present or not. In no case should tallow be used which shows any reaction with methyl orange, as mineral acids have a most disastrous effect on size. If acid be present its nature should be determined, the solution being divided into two equal portions for this purpose, and tested as follows:—

(a) HYDROCHLORIC ACID.—A few drops of nitric acid and a few drops of a solution of nitrate of silver should be added to one portion of the solution. If

hydrochloric acid be present, a white curdy precipitate is produced. (N.B.—This test is accurate only if other chlorides, such as magnesium and calcium chlorides, and common salt, be absent).

(*b*) SULPHURIC ACID.—A few drops of hydrochloric acid, and a few drops of a solution of chloride of barium should be added to the second portion of the solution. If sulphuric acid be present, a heavy white precipitate of sulphate of barium will be produced.

TESTS FOR THE CHLORIDES OF MAGNESIUM AND CALCIUM.—These substances may be extracted by boiling a sample of the tallow in water, as described on page 177. After cooling, the liquid is filtered from the fat, and tested for calcium and magnesium, as follows:—A strong solution of chloride of ammonium and an excess of a solution of ammonia should be added, and afterwards an excess of solution of oxalate of ammonium. If calcium be present, a white precipitate will be formed. The mixture should then be filtered, and a solution of phosphate of sodium added. If magnesium be present, a white granular precipitate of magnesium ammonium phosphate will be formed.

The presence of the various chlorides may be determined by testing a portion of the liquid with nitrate of silver and nitric acid. In the absence of calcium and magnesium, the production of a large amount of the curdy white precipitate of chloride of

silver would indicate the presence of common salt. This should be confirmed as follows :—

TEST FOR CHLORIDE OF SODIUM (COMMON SALT). A portion of the solution, obtained by boiling the tallow in pure water, should be evaporated to dryness on the water bath. The residue is dissolved in as small a quantity of water as possible, filtered, and the solution poured into a long narrow test tube. To this should be added twice its bulk of strong hydrochloric acid. A white granular precipitate will be formed if common salt be present. Precipitation will take place, by this treatment, in the presence of the chlorides of magnesium and calcium.

MINERAL MATTERS—(CHALK, BARYTES, etc.)—These substances may be detected as follows:—5 or 10 grammes of tallow should be dissolved in petroleum spirit, filtered, and the residue examined. A portion treated with hydrochloric acid will effervesce if chalk be present, whilst barytes will remain as an insoluble residue.

DETERMINATION OF THE PERCENTAGE OF WATER IN TALLOW.—If water has been detected in the preliminary examination of the tallow the amount should be determined quantitatively as follows :

About five grammes of tallow should be carefully weighed in a tared evaporating basin, along with a glass rod, the weight of which has been taken. The basin and contents are then placed on the sand bath and heat applied, care being taken that

the temperature of the tallow does not rise much above 212° Fah.

When the tallow melts, globules of water will be seen at the bottom of the basin, and as the temperature increases, these will break up and pass away in the form of steam. The tallow should be constantly stirred until the whole of the water has evaporated, a point easily seen if the tallow be allowed to remain undisturbed for a few seconds whilst the heating is continued. If the water has disappeared the tallow will be quite clear, and no further steam bubbles will rise to the surface. The basin and contents, with the glass rod, are allowed to cool, then weighed, and the loss in weight, which will be the water, is calculated to a percentage of the tallow taken.

This test will not be accurate should there be present a low vaporising mineral oil, but even in this case it will be sufficiently accurate for all practical purposes, as it still represents loss at a temperature of 212° Fah.

TEST FOR RECOVERED YORKSHIRE GREASE.—This substance is very frequently used for the purpose of adulterating tallow, and it is a most objectionable ingredient. Tallow mixed with this “recovered” grease is generally of a very bad colour, and it often contains a large percentage of unsaponifiable matter. It also frequently contains mineral oil, due to the use of adulterated oil for

scouring purposes, and on this account may be detected in the preliminary examination by means of the vaporising test. The fatty acids obtained from tallow, adulterated with Yorkshire grease, are dark coloured, sometimes of a deep orange, and frequently black. Yorkshire grease contains a large percentage of free fatty acids, and its presence in tallow may be detected by estimating the quantity of the acids contained therein, as described on page 186 *et seq.* Samples of *so called pure tallow*, sold at pure tallow prices, are frequently submitted to the writer, and on analysis are found to contain 60 to 70 per cent. of free fatty acids.

It is interesting to know how the olive oil used in wool scouring comes to be adulterated with mineral oil. Buyers request to be supplied with a 60 per cent. saponifiable oil. Pure olive oil should be practically entirely saponifiable, and in order to produce a 60 per cent. saponifiable oil, the dealer must use mineral oil. Why 60 per cent. should be stated no one knows. Possibly this accounts for the bad colours complained of in the Bradford trade.

TEST FOR COTTON SEED OIL STEARINE:—Cotton seed oil stearine is extensively used for the purpose of adulterating tallow. It is lower in price than pure beef or mutton tallow but higher in price than “recovered Yorkshire Stearine.” Its presence may be ascertained and the amount approximately

determined by estimating the quantity of free fatty acids, as described on page 186 *et seq.* A high percentage of free fatty acids, together with the absence of unsaponifiable matter (always found when "Yorkshire Stearine" is present), is a fairly certain indication of the presence of cotton seed oil stearine.

The principal objection to cotton seed oil stearine in tallow is that it is an adulterant. Another objection is that it is likely to produce a rancid smell in the cloth after it has been stored for some time.

DETERMINATION OF THE PERCENTAGE OF MINERAL OIL AND WAX IN TALLOW.—The percentage of mineral oil or wax in a sample of tallow may be determined as follows:—About 5 grammes of tallow should be carefully weighed and saponified with an alcoholic solution of caustic potash.

The potash solution is made by dissolving 80 grammes of the alkali in one litre of methylated spirit, the spirit having previously been de-hydrated by the following treatment:—

Methylated spirit is digested with a large excess of dried carbonate of potassium for some time. The spirit is then decanted into a suitable flask, a little caustic potash added, and allowed to stand for a day or two. The flask is then connected with a Liebig's condenser and a receiver, and the spirit distilled off. This de-hydrated spirit should be stored in well-stoppered bottles, and may be used for making the standard potash solution, which is used when

determining the saponification equivalent of tallow and of other fats and oils.

The operation of saponification may be conducted in a porcelain basin on the water bath. About 30 c.c. of the potash solution is added to the tallow and kept constantly stirred with a glass rod, until the alcohol is nearly driven off and the residual liquid froths strongly. If incomplete saponification be suspected, 10 or 15 c.c. of potash solution is again added and the evaporation repeated. The soap produced should be diluted with warm water, and transferred to a stoppered pear-shaped glass separator of about 200 to 250 c.c. capacity, to which is fitted a tap. The basin should be rinsed out with more water, to ensure the complete removal of the soap, and the washings added to the contents of the separator. If the fat or oil be free from mineral oil or wax, the solution will be perfectly clear, but if mineral oil be present globules of it will be seen in the solution. About 50 c.c. of ether should next be added, and the mixture thoroughly shaken and allowed to stand. The liquid will readily separate into two distinct layers, the ether, containing the mineral oil, floating on the top of the soap solution. The soap solution is carefully run off into another separator and about 10 c.c. of water added to the ether in the first one. This is again well shaken and the washings are run off into a separator containing the soap.

The solution of mineral oil in ether is poured through the mouth of the separator into a tared evaporating basin, and the soap solution is treated with more ether, separation takes place as before, the soap solution is again run off into a separating funnel, and the ether solution washed with water. The wash water is run into the soap solution, and the ether poured into the evaporating basin or flask containing the product of the first separation. The process is repeated a third time when all mineral oil will be removed from the soap.

The ether solution is evaporated on the water bath, or, better and safer, and with less waste, the evaporation is conducted in a flask, to which is fitted a condensor. When the ether has been distilled off, as far as possible, a current of air is blown through the flask until the smell of ether disappears. The flask is weighed and the tare deducted. The weight of mineral oil found is calculated to a percentage of the tallow originally employed.

DETERMINATION OF THE COMBINED FATTY ACIDS IN TALLOW.—The soap solution from the previous test should be placed in a separating funnel and an excess of sulphuric acid added. After shaking up, a quantity of ether is poured into the separator and well agitated. The mixture is allowed to settle until the separation of the ethereal layer is complete. The aqueous solution is then carefully run off. A few drops of chloride of barium solution, and a

quantity of water, should now be added to the ethereal solution in order to precipitate, as barium sulphate, any excess of sulphuric acid. This may be removed afterwards along with the water. The ethereal solution of fatty acids should be washed two or three times with water, and finally transferred to a tared basin or flask, and the ether removed by evaporation, with the precautions previously described. The weight of the residue having been found, it is calculated to a percentage of the tallow originally taken.

The following method is a simpler one for determining the combined fatty acids in fats and oils, provided mineral oil or paraffin wax be absent :—

An evaporating basin and a glass rod should be carefully weighed. About 5 grammes of the fat or oil is then placed in the basin and the whole weighed again ; the difference in weight gives the amount of fat taken. This is then converted into soap with alcoholic potash as previously described. The soap is dissolved in hot water, and an excess of hydrochloric acid added. This decomposes the soap, combining with the potash to form chloride of potassium, whilst the fatty acids are liberated. These are allowed to cool, and when thoroughly cold the cake of fat should be lifted out, by means of the glass rod, and the hydrochloric acid and water remaining, poured away. Sometimes, as in soft soap,

and also in the case of hard soaps made from oils, the fat does not set hard on cooling. In such cases it will be necessary to add a weighed quantity of bees wax; about 2 or 3 grammes, after the fatty acids have been liberated, in order to cause them to solidify on cooling. After cooling, the whole is re-melted in contact with water, and well stirred, in order to wash out all traces of hydrochloric acid. The mixture is again allowed to cool, the fat and wax removed as before, and laid upon a sheet of clean blotting paper, which absorbs the moisture. The water in the basin is then poured out, care being taken that no particle of fatty acids is lost. The bottom and sides of the basin are then carefully dried by means of blotting paper. The cake of fat is replaced and carefully heated. If any water remain, crackling will commence, in which case the melted fat should be rapidly stirred to prevent spurting, until the water is evaporated. The whole should be allowed to cool, and then carefully weighed.

The weight of the basin and rod, and the weight of the bees wax (if this latter substance has been added) is deducted from the total weight, the remainder being the weight of fatty acids originally combined in the tallow. This weight should be calculated to a percentage.

DETERMINATION OF FREE FATTY ACIDS IN TALLOW.—This test is an important one because tallow frequently contains free fatty acids, due to

the practices of adulterating it with "recovered Yorkshire stearine" and cotton seed oil stearine.

The proportion of fatty acids may be quantitatively determined by dissolving a weighed quantity of the sample in alcohol (de-hydrated methylated spirit) and titrating with alcoholic soda solution of known strength, using phenol-phthalein as indicator. The following are the details of the method, which was first proposed by Hausamaun :— Methylated spirit is purified by re-distillation with a little caustic soda. A small quantity of phenol-phthalein is added, and then dilute caustic soda, drop by drop, until the liquid retains a faint pink colour after shaking. This preliminary treatment of the alcohol is intended to secure the absence of any free acid. An accurately weighed quantity of the sample, about 5 grammes of a fatty acid or 50 grammes of an ordinary oil or fat, is then introduced into a flask furnished with a glass stopper. From 50 to 100 c.c. of the neutralised spirit is then added, and raised to the boiling point by immersing the bottle in hot water. The contents are thoroughly shaken, in order to effect the complete solution of the fatty acids present. If the sample be entirely free from fatty acids, the pink colour will remain, otherwise it will have disappeared. In the latter case a decinormal solution of caustic soda ($= \cdot 004 \text{ NaHO}$ per cubic centimetre) is gradually added from a burette until the pink colour is just

restored. Each c.c. of decinormal soda = $\cdot 0282$ oleic acid or $\cdot 0284$ of stearic acid.

DETERMINATION OF THE SAPONIFICATION EQUIVALENT OF TALLOW.—The following method, described by Koettstorfer, may be used:—3 or 4 grammes of the tallow should be carefully weighed in a small glass flask of about four ounces capacity. 30 c.c. of seminormal solution of caustic potash in alcohol is added from a fine burette. The flask is fitted with a cork through which is passed a long glass tube. The flask and contents are heated on the water bath for half-an-hour, or until the saponification is judged to be complete. The contents of the flask should be continually rotated. A blank experiment is conducted at the same time by heating 30 c.c. of the same alcoholic potash in a similar flask fitted with a cork and long tube. 1 c.c. of an alcoholic solution of phenol-phthalein is then added to each flask, and both titrated with seminormal hydrochloric acid. The difference in the number of cubic centimeters of acid employed in the two testings represents the number of cubic centimeters of alkali combined with the fat. Each c.c. of seminormal acid = $0\cdot 01825$ of HCl and represents $0\cdot 02805$ of KHO. From the data arrived at, the percentage of caustic potash required to saponify the fat can be readily calculated.

The saponification equivalent is found by dividing the weight of the sample employed, expressed

in milligrammes, by the number of c.c. of normal acid (not seminormal) corresponding to the alkali neutralised by the oil or fat. If the percentage of potash required be known, the saponification equivalent can be found by dividing this percentage into 5610. The amount of caustic potash required to saponify tallow is from 19·3 per cent. to 19·8 per cent. The saponification equivalent is from 283 to 290. If a tallow be saponified with half the above percentage of caustic potash, it would probably mean that 50 per cent. of unsaponifiable hydro-carbon (mineral) oil was present.

SPECIFIC GRAVITY OF TALLOW.—Important evidence of the purity of a sample of tallow may be obtained by taking the specific gravity. The following is the best method of procedure:—A specific gravity bottle, with a well-fitting perforated stopper, is charged with the melted fat in the ordinary way. In the meantime a large glass beaker, or other suitable vessel, is filled with water and set to boil over a Bunsen's flame.

When the water begins to boil, the charged specific gravity bottle is immersed in the water by means of a pair of tongs, and the boiling briskly continued. The heated fat expands, and, by passing through the stopper, prevents any water making its way into the bottle. The tallow should be boiled for just twenty minutes. The bottle is then taken out, rapidly wiped dry, cooled, and weighed. The

weight, less the tare of the bottle, gives the weight of fat it holds at the boiling point of water. This, divided by the weight of water held by the bottle at 60° Fah., gives the specific gravity. Tallow has a specific gravity of .857 to .862 taken under these conditions. In the case of oils the specific gravity is taken in the ordinary way at 60° Fah.

The tests described under tallow may be applied to the other oils, fats and waxes, used in sizing, and the results compared with the table at the end of this chapter.

TALLOW SUBSTITUTES.

Whenever the price of tallow advances, large numbers of cheaper substitutes are put upon the market for sizing purposes. Some are sold as substitutes, whilst others are used for the purpose of adulterating tallow.

Innumerable attempts have also been made to bring out some substitute for tallow which would give similar results at a reduced cost. So far they have all signally failed in achieving this object, and manufacturers would be acting in their own interests if they left these preparations severely alone.

No substance has yet been placed upon the market which will give as good results as tallow for any class of sizing where chloride of magnesium or

chloride of zinc are constituents of the size mixing. It is impossible to obtain anything like the softening effects by substituting soap or tallow substitutes of any description. In the case of good honest soap the sizer knows, at any rate, what he is purchasing, but in the case of tallow substitutes he is generally paying a high price for absolute rubbish.

Tallow substitutes are generally made by boiling together tallow, caustic soda, and water. Sometimes a little gum tragacanth, starch, and glycerine, is added to the mixture. As a rule, these various tallow substitutes contain a little free alkali, sometimes they contain free fat, and not uncommonly they contain both free alkali and free fat. This latter condition is owing to the fact that the mixture has not been properly boiled. If fatty matter be mixed with soap and water, it is possible to obtain a substance which is fairly hard, and shows little or no evidence of the presence of an excessive quantity of water.

	No. 1 per cent.	No. 2 per cent.	No. 3 per cent.	No. 4 per cent.
Actual Dry Soap	26'58	9'30	22'10	5'78
Free Caustic Soda	0'26	0'25	0'50	0'74
Water.....	73'16	90'45	72'50	45'44
Glycerine .....	...	...	4'90	...
Free Fatty Matter.....	...	...	...	48'04
	100'00	100'00	100'00	100'00
Combined Fatty Acid...	23'40	6'86	18'3	...

From the preceding figures it will be seen that only one of these so-called tallow substitutes contained free fat at all. They are simply badly prepared low class soaps, in which water is the predominating ingredient. For heavy or medium sizing they are almost useless ingredients. They might be useful in pure sizing, if used in conjunction with tallow, but it would be far better and cheaper for the manufacturer to purchase a good hard soap, or good soft soap, and dilute with water himself. The samples marked No. 1 and No. 2 were supposed to be the same substances, but the manufacturer, becoming suspicious that the quality was not being kept up, sent the writer samples from different consignments. It was found that No. 2 contained only one-third of the amount of active ingredient contained in No. 1.

If manufacturers were desirous of using such substances as either of the stronger tallow substitutes, they could be easily prepared by boiling up a good hard soap with water. The following proportions would be suitable:—

White hard soap	...	...	...	30 lbs.
Water	...	...	...	7½ gallons.

To this mixture about a quarter-of-a-pound of powdered caustic soda should be added. The addition of about 5 per cent. of glycerine would improve the weaving.

The value of most of the tallow substitutes depends upon the amount of soap contained therein, and as a good hard soap contains from 60 to 70 per cent. of fatty acids in combination, as against 6·8 to 23·4 per cent. found in many tallow substitutes, as shown by the above analyses, it would be to a manufacturer's or sizer's advantage to make his own tallow substitute, especially as by doing so he is not tied to one individual for his ingredients, nor is he dependent upon anyone for his results.

Another class of tallow substitute is made by emulsifying mineral oil. This is manufactured as follows:—The moisture is removed from soap as nearly as possible by drying. A known weight of mineral oil, ·885 specific gravity, is heated to about 180° Fah., and to every 56 lbs. of oil about half-a-pound of the dried soap is added, and the heating continued until the soap is dissolved in it. The mixture is then allowed to cool, the product being a grease of great body. Sometimes paraffin wax is added to give extra solidity. There are the same objections to the use of this form of tallow substitute as there is to the use of mineral oil.

BONE AND MARROW FATS.

These substances are obtained by boiling the bones of various animals in water under pressure, or by the action of solvents, such as benzene, etc.

BONE FAT—BONE GREASE.

This substance is generally dark in colour, and unpleasant in smell; this latter characteristic being due to its contact with decomposed animal matter, such as blood. Bone fat is softer than tallow, melting from about 100° to 104° Fah. It also has a lower vaporising point. Except for these points, and for the fact that it contains phosphate of lime (phosphate of calcium), it could not be distinguished chemically from tallow. Occasionally bone fat is purified by treating it with hydrochloric acid. This dissolves the phosphate of calcium, which may then be removed by washing with water.

MARROW FAT.

Marrow fat is generally of a creamy tint, and has a peculiar granular appearance when cut. The same characteristic appearance is seen in home-rendered dripping. Even after re-melting the granular appearance shows on cooling. Round each granule there appears to be a more oily fat. Marrow fat melts at a lower temperature than bone fat. It contains phosphate of calcium, the test for which has been described under tallow. It may be used in sizing for the same purpose as bone fat. Marrow fat is generally of a good colour, and it is free from objectionable smell. For this reason, it may be used as the "softening agent" in any class of sizing.

COCOA-NUT OIL.

Cocoa-nut oil is occasionally used as a "softener" in sizing. It is a white fat, having the consistency of lard or butter, and the characteristic smell of cocoa-nut. The melting point is low, and varies considerably, ranging from 68° to 82° Fah.

Cocoa-nut oil combines with alkalies, producing soaps. These soaps are sometimes known as marine soaps, due to the fact that they can be used with salt water. Unlike the solutions of soaps made from other fats and oils, cocoa-nut oil soap is not readily precipitated by means of salt solution. Cocoa-nut oil soap may contain a very much larger percentage of water than other soaps and yet remain hard. Cocoa-nut oil is largely used in sizing in conjunction with Epsom salts. It has the property of mixing more readily with this substance than any other oil or fat.

Sizing pastes, which consist essentially of cocoa-nut oil soap and water in which an excess of the oil is afterwards dissolved, are largely sold.

OLIVE OIL.

This oil is used in sizing, but only to a limited extent. It is frequently adulterated, the chief substances used for this purpose being mineral oil, cotton seed oil, poppy oil, sesame oil, and rape oil. Mineral oil may be detected generally by the

fluorescent appearance of the sample, unless a bloomless mineral oil has been used. In any case, its presence may be detected by taking the vaporising point. The other adulterants are less easily detected, and should be left to the trained analyst.

PALM OIL.

This oil, when bleached, is used extensively in sizing. It varies considerably in consistency, sometimes being as soft as lard, at other times as hard as tallow. The melting point varies to the same extent as the consistency. Unbleached palm oil varies in colour from a brownish yellow to a deep orange, and has a characteristic, but not unpleasant smell. The oil is frequently adulterated with water, the amount of which may be determined by the method described on page 179.

CASTOR OIL.

Castor oil is very rarely used in sizing, although it is largely used in the form of soluble oil and oleine oil by dyers and finishers. Castor oil possesses softening properties to a marked degree.

TURKEY RED OIL.

ALIZARINE OIL.—“OLEINE” OIL.

This substance is obtained by treating castor oil with strong sulphuric acid. It is occasionally used

as a softener in sizing, but more often in the finishing of cotton goods.

The following is the mode of procedure adopted in the preparation of “oleine” oil:—The castor oil and sulphuric acid are mixed together in lead-lined tanks, in which a stirring arrangement is fitted. The tanks are generally jacketed in order to allow water to be circulated for cooling purposes. 40 gallons of castor oil are run into the tank, and into this 10 gallons of sulphuric acid, Twaddelling 170° , are *very slowly* poured; the mixture being kept constantly stirred. This is allowed to stand for 12 or 14 hours, after which a solution of common salt, Twaddelling about 8° , is run in, well mixed, and again allowed to stand. The fatty acids will aggregate, and collect at the surface of the salt liquor. This liquor is then drawn off by means of a tap placed near the bottom of the tank. The operation of salting is repeated, and the mixture again allowed to settle, the salt liquor being drawn off as before. By the time the second washing has been completed practically the whole of the sulphuric acid should have been removed. It is now necessary to neutralise the free acids and make up to the desired strength. Caustic soda is usually the alkali employed for this purpose. Some manufacturers claim that liquid ammonia is better, and for certain work, particularly in calico printing, this probably is so, as the ammonia salts are more readily decomposed

during the steaming process, thus enabling the colour to take up the fatty acids more readily. In other cases, it is customary to almost neutralise with caustic soda solution, and complete the process by the careful addition of liquid ammonia. Care is required in the operations involved.

When the fatty acids have been neutralised, the "oleine" is diluted to a certain strength with water. The standard strength generally contains 50 per cent. of fatty matter. The "oleine" is made entirely soluble by means of a solution of ammonia which is added until the "oleine" becomes quite clear.

"Oleine" oil is chemically a salt of sulphuric-oleic acid, $C_{18}H_{23}(HSO_3)O_3$. Sometimes it is the ammonium salt, but generally it is a mixture of ammonium and sodium salts, according to the method of preparation.

"Oleine" oil, being soluble in water, may be used to advantage in very light sizing where it is desired to preserve the lustre of the fabric. In such cases it is used in conjunction with white dextrin and starch. "Oleine" oil must not be used as an ingredient of the size if zinc, calcium, or magnesium salts, are present.

SOLUBLE OIL.

This preparation is usually made from castor oil. Occasionally maize or other oils are used, but the product is not equal in quality to that made from

castor oil. Soluble oil, made from castor oil, is really a castor oil soap. It is prepared by boiling castor oil with a solution of caustic soda. The soluble oil should be free from alkali, any excess of this substance being neutralised, either by the addition of more castor oil, or by the cautious addition of acetic acid to the hot solution.

The following proportions of the ingredients may be used in the preparation of soluble oil :—

SOLUBLE OIL.

Castor Oil 2 gallons.

Caustic Soda Solution at 40° T. 9 pints.

Boil the above for one hour and then add

Hot Water 7 gallons.

Soluble oil is occasionally used as a “softener” in sizing.

“STEARINE”—STEARIC ACID.

The “Stearine” of commerce, and the one employed in sizing, generally consists of a mixture of free stearic and palmitic acids. Sometimes oleic acid is also present.

“Stearine” is largely prepared from cotton seed oil. It is a bye-product in the purification of this substance. The oil is agitated with a 10 or 15 per cent. solution of caustic soda at the ordinary temperature. The alkali combines with the colouring matter, and at the same time saponifies the free fatty acids. This colouring matter, with the soap, is

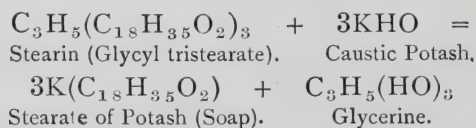
deposited. After the purified oil has been removed, the deposit is treated with sufficient sulphuric acid to decompose the soap. The fatty acids liberated are then heated with concentrated sulphuric acid to about 250° Fah. This treatment renders the colouring matters insoluble, and the fatty acids float on the surface of the mixture. They are then removed, and distilled with superheated steam. The stearic acid is generally separated from the mixture of stearic and oleic acids by pressure.

Stearic acid is frequently adulterated with mineral oil and paraffin wax, for which substances it should be tested by the methods described under tallow. It is itself used as an adulterant of tallow.

Stearic acid, free from oleic acid, melts at about 158° Fah., but this is not the ordinary commercial form as used for sizing purposes.

PURE STEARIN.

This substance is entirely different from the "stearine" of commerce. It constitutes the less fusible portion of solid fats such as tallow, and is known chemically as tristearin, or glyceryl tristearate. It occurs largely in conjunction with tripalmitin and triolein in the natural fats. When tristearin is decomposed with caustic alkalies, glycerine is formed.



SPERMACETI.

Spermaceti is fairly extensively used as a "softener" in some districts. Why this is so is more than the authors can say. In the first place, it is far too expensive a substance to employ for such a purpose, and in the second place, it is generally used in conjunction with tallow and paraffin wax, but in so small a proportion to the total quantity of size present, that any special properties it may possess are utterly lost. The use of spermaceti is merely a superstition, and its qualities may be equalled by using a mixture of tallow and paraffin wax, or by using either of these substances alone.

Spermaceti exists in solution, in the oil from the sperm whale, and other cetaceans, except the whale-bone whales. It occurs most abundantly in the oil obtained from the head cavities, and in a lesser degree from the blubber.

Spermaceti is a snow-white substance of marked crystalline structure. It melts from about 110 to 120° Fah. It is very liable to adulteration, the chief substances used for this purpose being stearic and palmitic acids, "stearine," tallow, and paraffin wax. The fatty acids may be detected by determining the amount of fatty acids present in the sample, as described on page 186; anything above 1 per cent. indicates adulteration with these substances. Tallow and "stearine" may be detected by the smell produced on heating the sample. The

proportion of these substances may be determined by treating with standard alcoholic potash solution and standard HCl as described on page 188.

Paraffin wax lowers the density of spermaceti, this being, in the case of true spermaceti, '942 to '946 at 60° Fah., whilst in the case of paraffin wax, it is '909. The presence of paraffin wax would also lessen the percentage of caustic potash required to saponify spermaceti, the amount required for the pure substance being, on an average, 12·8 per cent.

PARAFFIN WAX.

Paraffin wax is obtained in the manufacture of paraffin and petroleum. In the crude state it is a brownish soft scaly substance, and should never be used for sizing unless purified. Paraffin wax varies greatly in quality, the quality depending upon the melting point. A good class wax for sizing purposes melts at from 120° to 125° Fah. For pharmaceutical purposes a much higher melting point is required, viz.:—130° to 140° Fah., but this wax is too dear for ordinary commercial use.

Usually four qualities of wax are manufactured, the best commercial samples melt at 120° to 125° Fah., the second 115° to 120° Fah., the third at 110° to 115° Fah., and the fourth at 100° Fah.

Paraffin wax gives off vapour at low temperatures, the temperature depending upon the quality

of the wax. The average vaporising point is from 210° to 220° Fah.

Paraffin wax is very extensively used in sizing, but it should never be used where the cloth is intended to be bleached, dyed, or printed. Paraffin wax is unsaponifiable, and consequently it cannot be removed by boiling with caustic soda, lime, or soda ash. The mechanical action of boiling may remove a certain quantity of the wax, if the liquor in the kiers is discharged at the top by forcing fresh water in at the bottom, But if, as is usually the case, the liquor is run off from the bottom, the bulk of the paraffin wax will settle on the cloth at the top of the kier. This will give rise to patchy places in the dyed and finished fabrics. Even where there is a trace only of paraffin wax left in the cloth the colour will not take evenly when the fabric is dyed or printed.

Paraffin wax is largely used for sizing coloured yarns for dhootie bordered goods. It lays the fibres of the yarn rather better than tallow, and, as these yarns are generally sized with as small a percentage of size as possible, it enables them better to resist the rubbing of the healds and reed.

Occasionally cloth sized with a mixing containing paraffin wax becomes yellow on keeping. This objectionable colour is due to the fact that the wax has not been sufficiently refined.

JAPAN WAX.

Japan wax is obtained from the berries of several species of *Rhus*. The crude wax is obtained in greenish tallow-like masses, and is purified by filtration and bleaching. Purified Japan wax is yellowish-white in colour, and it has a melting point of from 123° to 128° Fah. Japan wax may be saponified by boiling with caustic soda and caustic potash. By this treatment it yields fatty acids and glycerine. Japan wax is occasionally used in sizing. It is frequently combined with caustic soda and water, to form a soap. This soap is usually sold in the form of a paste, and it is mainly used for sizing woven coloured goods, such as flannelettes, etc. These preparations generally contain an excess of wax, dissolved, or emulsified, in the wax soap.

Japan wax is readily saponified in the bleaching operations when subjected to the lime boil. For this reason it may be used for goods intended to be bleached.

CLASSIFICATION OF FATS, OILS, AND WAXES USED IN SIZING.

Nature of Substance,	Source.	Specific Gravity.		Melting Point in degrees Fah.	Percentage of Caustic Potash (KHO) for Saponification.	Average Saponification Equivalent.	Percentage of insoluble Fatty Acids, combined and free.	Other characteristics.
		Water at 60° Fah.	At 210° Fah.					
TALLOW ...	From ox & sheep	942 to 943	860 to 862	108° to 118°	19·6 to 20·0	283 to 290	95 to 96	Commercially pure tallow rarely melts below 108°Fah., generally from 110° to 118° Fah.
BONE FAT ...	Bones of various animals	.....	.....	96° to 104°	19·5	294	96	Brownish or dirty white in colour, unpleasant smell, generally contains phosphate of calcium.
MARROW FAT	Bones of various animals	.....	.....	96° to 104°	19·5	294	96	Creamy white in colour, not unpleasant smell, granular appearance, generally contains phosphate of calcium.
“STEARINE” (Stearic Acid)	Cotton seed oil, <i>see page 199</i>	.....	.....	Varies according to composition.	Varies	Varies	Varies	Characteristic smell of stearic acid on heating; consists of a mixture of stearic and palmitic acids.
COCOA-NUT OIL	Nuts of <i>cocos nucifera</i>	·930	868 to 874	68° to 82°	24·60 to 26·80	209 to 250	83 to 88	White, consistency of butter, characteristic smell of cocoa-nut.
PALM OIL ...	Fruit of <i>elais guineensis</i>	920 to 927	857 to 859	77° to 96°	19·63 to 21·00	277 to 286	96·5	Natural colour, brownish yellow to deep orange red; always bleached for sizing purposes.
CASTOR OIL	Seeds of <i>ricinus communis</i>	950 to 970	909	.....	17·60 to 18·15	309 to 319	96·1	Very viscous, high specific gravity, forms an ether with sulphuric acid.
SPERMACEI	From oil of sperm whale	942 to 946	808 to 812	110° to 120°	12·3 to 13·4	432 to 441	52 to 53	Pure white in colour, with characteristic crystalline appearance.
JAPAN WAX...	Berries of <i>rhus succedanea</i>	984 to 1000	874 to 877	122° to 127°	21·01 to 22·25	255 to 267	.....

CHAPTER IV.

Soap.

THIS substance, either in the form of hard or soft soap, is very extensively used in sizing.

Soap is produced by boiling tallow, or some other form of animal, vegetable, or fish oil, in a solution of caustic soda or potash.

All fats and oils, other than hydrocarbon oils, and to a certain extent sperm oil, are combinations of fatty acids with glycerine. Caustic potash and soda have the powers of decomposing this combination. The alkali unites with the fatty acids, producing soap with the formation of glycerine. Other substances, such as oxide of lead, alumina, lime, etc., have this power of decomposing fats and oils, but in these cases insoluble soaps are produced. A typical instance of an insoluble soap is ordinary sticking plaster. This is an oleate of lead, and it is produced by boiling oxide of lead with olive oil.

Commercial soaps may be divided into two distinct classes, viz:—Hard soaps and soft soaps. The former are combinations of fats or oils with caustic soda, whilst the latter are combinations of oils with caustic potash.

HARD SOAP.

Hard soap is manufactured in enormous quantities in this country.

The following short description will give the reader some idea of the processes used in soap boiling:—The tallow, or other fat to be saponified, is introduced into the boiler, and the caustic lye added, after which the mixture is gently heated to the boiling point. As a rule a quantity of soap is added to the mixture in order to emulsify the fat, thus making it combine more readily with the alkali. After the mixture has boiled for a few hours, it forms a viscid emulsion, capable of being drawn out into thin threads. The soap in this emulsion is now in solution in the water, but the whole of the fat has not become completely saponified. In order to effect this the soap and uncombined fat must be separated from the spent lye, so that a fresh solution of alkali can be added. For this purpose a quantity of common salt is added. This dissolves in the water, and causes the soap and unsaponified fat to rise to the surface. The operation of boiling with caustic lye is repeated to complete the saponification, and the soap separated as previously described. It is then allowed to partially cool, and afterwards ladled out into buckets and conveyed to the frames in order to completely cool and set.

The following analyses give some idea of the average composition of white hard soap. It may be well to state here that soap made from cocoa-nut oil will retain more water and remain harder than that made from any other oil or fat.

Variety of Soap.	Fatty Acids. per cent.	Dry Soda. per cent	Water per cent.	Analyst.
Castile soap	76·5	9·0	14·5	Ure.
Castile soap	75·2	10·5	14·3	„
White toilet soap.....	75·0	9·0	16·0	„
Ordinary white soap.....	60·0	6·4	33·6	„
Resin soap	76·0	8·9	15·1	Percy Bean.
Cocoa-nut oil soap	22·0	4·5	73·5	Ure
Good white tallow soap...	76·3	8·9	14·8.	Percy Bean.
White soap	50·2	4·6	45·2	Thenard
Tallow substitute, No. 1...	23·4	4·28	72·32	Percy Bean.
do. do. No. 2...	6·86	2·69	90·45	„
do. do. No. 3...	18·30	4·20	71·50	„

It will be seen that good hard soaps contain from 60 to 76 per cent. of fatty acids, and in very dry samples which have been kept some years, as much as 81 per cent. has been found by the writer. The tallow substitutes have been included under soaps, in order to make a comparison of their values. The sample No. 3 contained small quantities of glycerine and gum in addition to the substances enumerated.

SOFT SOAP.

Soft soap is produced by boiling caustic potash with oil, such as hemp seed, linseed, or fish oil, etc. The nature of the oil employed is indicated by the smell or colour of the soap. Generally hemp seed oil produces a soft soap which possesses a rich green colour. Linseed oil soap is brown, whilst fish oil soaps are easily recognised by their smell. Soft soaps always remain soft if prepared from caustic potash, and they are less often adulterated than hard soaps. Any addition of water would be evident by the fluid condition of the soap. Occasionally the writer has come across soft soap adulterated with a large quantity of silicate of soda. These soaps have been poor in appearance, and very often a large amount of a slimy deposit is found at the bottom of the cask. Soap containing silicate of soda should not be used for sizing purposes.

Soft soaps are hygroscopic, *i.e.*, they absorb water from the atmosphere. Hard soaps, on the other hand, give off their excess of water, losing considerably in weight. These properties are very characteristic of other potash and soda salts. Carbonate of soda or washing soda gives off its water of crystallisation, whilst carbonate of potash absorbs water.

Many manufacturers judge the value of a soft soap by its appearance, and take as a standard the transparency of the green or brown mass, and the amount and appearance of white granules contained

therein. The latter appearance is known in the trade as "figging." The granules are produced by adding tallow to the soap just before the boiling operation is completed. The tallow forms stearate of potash. These granules make their appearance only after the soap has been manufactured for some time, and in hot weather they are not produced at all. The probability is that this appearance of "figging" has been made a standard of quality by buyers, because certain firms of soap makers, who have a good reputation, have affected this class of soap, and consequently it has got a good name. Unfortunately, inferior soaps have been put upon the market, and starch has been used to produce the desired "figging" effect, consequently this peculiar appearance must not always be looked upon as a sign of good quality.

In the manufacture of soft soap, the soap is not separated from the lye, as is the case in the manufacture of hard soaps, the main object in the production of soft soap is to combine the caustic potash with the fat or oil. Soft soaps, therefore, contain the whole of the base of the oils, *i.e.*, the glycerine, as well as the impurities existing in the lye, such as carbonate, chloride, and sulphate of potassium, etc., as well as a certain amount of free caustic potash. Soft soaps always contain more water and free alkali than ordinary hard soaps.

The following analyses show the composition of good ordinary soft soaps.

Variety of Soap.	Fatty Acids. per cent.	Dry Potash. per cent.	Water. per cent.	Analyst.
Soft soap.....	44'0	9'5	46'5	Thenard.
London soft soap.....	45'0	8'5	46'5	Ure.
Green soft soap	36'0	7'0	57'0	„
Scotch soft soap	47'0	8'0	45'0	„
Scotch rape oil soap	51'6	10'0	38'3	„
Scotch olive oil soap	48'0	10'0	42'0	„
Ordinary soft soap, No. 1	44'4	9'3	46'3	Percy Bean.
do. do. No. 2	42'6	9'0	48'4	„
do. do. No. 3	39'4	8'8	51'8	„

ANALYSIS OF SOAP.

Soap is frequently adulterated. It is therefore necessary that it should be systematically analysed.

The following process is simple, and suitable for the analysis of ordinary hard or soft soaps (Muter): Cut the sample across, and drop on the fresh surface a solution of phenol-phthalein in alcohol, when any red colour shows the presence of free alkali. If free alkali be found, dissolve 5 grammes in absolute alcohol, add phenol-phthalein, titrate with decinormal acid, and calculate to NaHO, or KHO, according to which alkali is present.

Dissolve 2 grammes of the soap in absolute alcohol by the aid of heat, add a drop of phenol-phthalein solution, and pass CO₂ till any red colour

disappears. Filter through a tared filter, and wash any insoluble matter found with warm alcohol, dry at 212° Fah., and weigh. This will give total impurities (such as alkaline carbonates, silicates, or borax). The filtrate and washings are then evaporated on the water bath, in a weighed platinum or porcelain dish, the residue being dried in the water oven to constant weight, and weighed = actual real soap present. The dish and contents are then gently heated to redness, the residue left being dissolved in water, and titrated with decinormal acid, using methyl orange as the indicator. The number of c.c. used is multiplied by $\cdot 0031$ for hard soda soaps, or by $\cdot 0047$ for soft potash soaps, and the resulting amount of alkali being deducted from the weight of real soap found, the difference $\times 1\cdot 03$ = amount of fatty acids. The weights of real soap and total impurities added together, and deducted from 2 (the amount of soap taken) gives the water present in the sample. Finally, everything is calculated to a percentage.

As a general rule the value of a soap for sizing purposes may be ascertained by determining the amount of combined fatty acids present.

For this purpose about 10 to 15 grammes of soap should be operated upon. In the case of hard soap the sample should be cut from the middle of the piece, and in fine shavings. A porcelain evaporating basin and a glass rod are carefully weighed together, the soap added, and the whole weighed again. The

difference in weight gives the amount of soap taken. A little water is added, and the basin and contents heated on the water bath until the whole of the soap has dissolved. Hydrochloric acid is then added, and the whole well stirred, the heating being continued for a few minutes longer. The hydrochloric acid combines with the soda or potash of the soap and liberates the fatty acids, which float on the top of the water. The basin is allowed to cool, and when thoroughly cold, the cake of fat should be lifted out with the stirring rod, and the excess of hydrochloric acid and water poured out. (In the case of soft soap the fatty acids are fluid, and it is necessary to add a weighed quantity of bees-wax in order to solidify them, as described later). Pure water is added, and the cake of fat re-melted in order to wash out all trace of hydrochloric acid. It is again allowed to cool, the fat removed as before and laid upon a piece of clean white blotting paper which will take up most of the moisture. The water in the basin is now poured out, taking care that no particles of fat are lost. The bottom and sides of the basin are then carefully dried with blotting paper, and the fat replaced and carefully heated. If any water remains, crackling will commence, and the melted fat must be rapidly stirred, to prevent spitting, until the water is evaporated. This will be evident when the crackling ceases. The whole should be allowed to cool, and then carefully weighed.

The weight of the basin and rod deducted from the total weight gives the weight of fatty acids present in the soap. This should be calculated to a percentage.

Sometimes the fat does not set solid, especially in the case of soft soaps. When this is the case, 5 or 6 grammes of white bees-wax should be carefully weighed and added to the hot fatty acids and water, the whole being well stirred until the wax and fatty acids are mixed. The mixture is allowed to cool as before, and washed and dried as described. The weight of wax must be added to the weight of the evaporating basin and glass rod, and deducted from the total weight, the difference giving the proportion of fatty acids combined in the soap.

Whenever a low percentage of fatty acids is found a correspondingly high percentage of water may be expected. The amount of water present may be roughly ascertained by drying a carefully-weighed sample of the soap in the steam oven for four or five hours. The loss of weight represents water, but not all the water. It is near enough, however, for all practical purposes. The same precautions should be taken in making the weighings for estimation of moisture as described under flour.

USE OF SOAP IN SIZING.

The value of soap as a sizing ingredient depends entirely upon the object for which it is used, and also to the presence or absence of certain ingredients.

Soap has the power of readily dissolving tallow, and so causes the fat to mix better with the flour or other starchy matter. It is also claimed that soap causes China clay to boil thinner, and at the same time prevents the clay from spiriting. The latter result is of no practical value as it is only necessary to place a lid over the clay pan to prevent spiriting.

For light sizing, soap is a most useful ingredient but it should never be used if chloride of magnesium, sulphate of magnesium, chloride of calcium, or chloride of zinc, are ingredients of the size. These substances decompose soap, with loss, both to the properties of the salts themselves, and to the utter destruction of the properties peculiar to soap. If magnesium and zinc salts are in excess, the whole of the soap is converted into a magnesium or zinc soap, which differs entirely from the original soap. Its power of emulsifying fat is lost, and instead of being useful as a "softener," it becomes harsh and difficult to mix with the size. In other words, the use of soap in medium and heavy sizing is an absolute loss, and needless expense.

As previously stated, soft soap possesses deliquescent properties and for this reason it is a more suitable substance to use in sizing than hard soap.

In conclusion it may be as well to warn manufacturers against the use of soft soaps prepared from fish oils. They usually possess a very strong and objectionable smell which is imparted to the cloth,

and this smell becomes intensified according to the length of time the cloth is kept. The writer knows of many instances where cloth has been rejected on account of its objectionable smell, due to the use of soft soap prepared from fish oil.

CHAPTER V.

*Deliquescent Substances,
used for softening and for giving
strength and weight to the Yarn.*

THIS class of sizing ingredients is in general use where much weight of size has to be put on the yarn. It is evident that where a large amount of starchy matter and mineral matter are constituents of a size mixture, some substance must be used to counteract the harshness, and consequent tendency to bad weaving, which is produced.

The following are the most important of these substances:—Chloride of magnesium, chloride of calcium, and glycerine. They are highly hygroscopic bodies, and by their powers of absorbing moisture from the atmosphere of the weaving shed they soften the yarn, and at the same time greatly strengthen it, thus enabling it to weave easily and well.

CHLORIDE OF MAGNESIUM—

“ANTISEPTIC.”

Chloride of magnesium is the most important deliquescent substance used in sizing. It received the name of “antiseptic” when it first came into use. Why this name came to be given to it the authors are at a loss to understand. Its properties in cloth are entirely the reverse of those of a true antiseptic. Instead of preventing the growth of mildew, it has a strong tendency to assist it. The substance itself does not mildew, but, on account of its power of absorbing moisture, it causes the starchy matter to do so, unless there be present some real antiseptic substance such as chloride of zinc. The authors feel that this book will have been of some little service if it only helps to kill that most misleading term, “antiseptic,” as applied to chloride of magnesium.

There is no doubt that the numerous cases of mildew which occurred 20 or 30 years ago were due to the use of this chemical by manufacturers who did not know its true action and properties.

Chloride of magnesium is a compound of the metal magnesium with chlorine gas, having the formula $MgCl_2$. It crystallises in needle-shaped crystals, having the following composition:—

	Per cent.
Chloride of Magnesium (real)...	46.80
Water of crystallization	53.20
	<hr/>
	100.00
	<hr/>

Commercial chloride of magnesium is very nearly pure, as the natural chloride of potassium found with it is too valuable a substance to be left unrecovered, and it is therefore carefully removed.

Chloride of magnesium is produced in large quantities at the salt mines of Stassfurt, in Prussia, where it occurs as the mineral "carnallite." This mineral has the following composition when pure, and may be looked upon as a double salt of magnesium and potassium, having the formula, $\text{MgCl}_2\text{KCl}, 6\text{H}_2\text{O}$.

	Per cent.
Chloride of magnesium	34'5
Chloride of potassium	26'76
Water	38'74
	<hr/>
	100'00
	<hr/>

The chloride of potassium is separated from the chloride of magnesium by crystallisation. The potassium salt is less soluble than the magnesium salt, and it therefore crystallises out of solution, leaving the magnesium salt in solution in the mother liquor. The liquor is drained off from the potassium chloride crystals, after which it is evaporated down to a certain specific gravity. It is then run into casks, where it crystallises into solid masses. In this state it is sent to England.

"Carnallite" is not found pure in nature, and there is often present small quantities of chloride of calcium, and the sulphates of soda, potash and lime.

Most of these impurities are removed by re-crystallisation, but there is generally a trace left. The following analysis represents a fair average sample of the chloride of magnesium of commerce :—

	Per cent.
Chloride of magnesium	46·40
Chlorides of sodium and potassium ...	1·98
Sulphates of potash and soda	·94
Water	50·68
	<hr/>
	100·00
	<hr/>

Chloride of magnesium is also manufactured in England by dissolving carbonate of magnesium in hydrochloric acid. The greatest care must be taken that no free acid is left in the finished article.

This prepared chloride of magnesium is generally sold in the form of a liquid, and some very good samples have passed through the writer's hands. It is necessary to take the specific gravity of this liquid to ensure getting the right strength. The English chloride of magnesium generally contains about 30 per cent. of real chloride of magnesium, as against 46 per cent. in the solid German chloride.

Although chloride of magnesium is rarely adulterated wilfully, it is necessary to apply the following tests.

(1) **SULPHATES.**—A small portion of the salt is dissolved in distilled water, and filtered if not clear. A few drops of hydrochloric acid and a few drops of barium chloride are then added. If a white precipitate

forms, sulphates are present. Most samples of chloride of magnesium will show a slight white precipitate, but this may be ignored.

(2) CHLORIDE OF SODIUM.--COMMON SALT.—A portion of the chloride of magnesium is dissolved in a test tube, with as little distilled water as possible. To this solution should be added twice its volume of strong hydrochloric acid. The mixture should be well shaken up. If salt be present as an adulterant, it will be precipitated, on account of the insolubility of common salt in hydrochloric acid. If common salt be not shown by this test, the sample may be passed as free. The test, frequently advised, of burning a portion on the end of a platinum wire in order to obtain the characteristic sodium flame (an intense yellow) is useless, as the slightest trace of salt is shown by this test.

In testing chloride of magnesium for common salt traces may be ignored, as people do not adulterate in traces. The special value of this test is apparent, because it passes over traces and detects adulterations. Its value is more apparent in the case of chloride of zinc. This substance is much more liable to adulteration with common salt than is chloride of magnesium.

(3) CHLORIDE OF CALCIUM.—This substance is frequently used as an adulterant in the liquid form of chloride of magnesium. It is very cheap, being a waste product in certain chemical manufacturing

processes, and it often contains very objectionable impurities, such as chloride of iron, and not uncommonly hypochlorite of calcium. In order to test for calcium it is necessary to add to the suspected solution, chloride of ammonium in excess, then a few drops of solution of ammonia, and finally a solution of oxalate of ammonium. A white precipitate will be formed if chloride of calcium be present. If the amount of the adulterant be required, the sample should be analysed in the usual way for calcium. Although chloride of calcium, when free from objectionable impurities, may possibly be as good as chloride of magnesium for some purposes, the sizer who has bought chloride of magnesium, should, under no circumstances, use a mixture containing a large quantity of chloride of calcium as it might change the entire character of a mixing.

Sometimes chloride of magnesium contains chloride of iron as an impurity. This is a very objectionable substance to have present, as it may give rise to iron-stains on the cloth. The method of testing for iron is given under chloride of zinc.

The presence of acid should always be tested for by means of blue litmus paper, as described on page 34. Acid is more likely to be found in the manufactured salt than in the natural German chloride of magnesium.

When chloride of magnesium is strongly heated

hydrochloric acid is liberated, consequently it should never be used for fabrics which are intended for bleaching, unless its presence is declared by the manufacturer. In the bleaching operation the goods are subjected to a great heat during the process of singeing. This heat is sufficient to decompose the chloride of magnesium, and the liberated hydrochloric acid will very quickly attack the fibre of the cotton and destroy it. Numerous cases of damage come under the writer's notice from the use of chloride of magnesium in goods which have undergone the operation of singeing.

If the presence of magnesium chloride was declared by the manufacturer it could be removed by washing and drying the cloth previous to singeing. This would add some cost to the bleaching operation, but it might be worth the while of the manufacturer to pay this charge, if only for the sake of the improvement in the weaving, and for the greater production which can be obtained from the looms where a small quantity of chloride of magnesium is present in the size.

Many attempts have been made to lessen the cost of a size mixing by substituting chloride of magnesium for tallow. Although chloride of magnesium has the power of softening the yarn, *it can never* be entirely used as a substitute for tallow or other oils. Up to a certain point it is an ideal softener, but if a great excess be used the yarn will become too damp, and

quite unfit for weaving. There is also the danger of iron-stains being produced if the amount of tallow in the size be reduced below a certain proportion. These iron-stains are caused through the metal parts of the looms rusting where the yarn comes in contact with them. For a time no trouble will arise, then iron-stains will begin to appear, and run through the weaving shed like an epidemic. The writer has been consulted in many cases where iron-stains have developed in a weaving shed, and where for months there has been no trace of this trouble. The tale is nearly always the same, *i.e.*, "that no change has been made in the mixing, and that the same thing has occurred before, but disappeared again without any apparent cause." In all such cases the size mixing in use is just on the danger point. If at any time there is an extra quantity of condensation of steam in the weaving shed at night, the moisture is attracted by the chloride of magnesium in the yarn, and deposited on the looms. The small proportion of tallow present in the size is not sufficient to protect the iron-work from rusting, and next morning the cloth will be found iron-stained, particularly in the reed, and on the back rest, and temple bar. This matter is further discussed under iron-stains.

Chloride of magnesium should never be used as an ingredient of size unless some antiseptic, such as chloride of zinc, is used with it. The authors know

of many cases where mildew has developed in pure sized cloth, and this has been caused by a small quantity of chloride of magnesium having got into the size accidentally. Generally it has occurred through using the same mixing beck for "pure" and heavy size mixings. Instead of cleaning out the beck thoroughly, a "pure" mixing has been made on the top of the remains of a heavier mixing which has contained chloride of magnesium. It is a very common practice, when changing a mixing, to run off the size from the beck as far as the tap at the bottom will allow, and then make a mixing of another character on the top of what is left. The manufacturer does not consider that he is running any risk by so doing.

As a matter of fact "pure" sized cloth will mildew more readily than heavily sized cloth if it becomes slightly damp, because, as a rule, it does not contain any antiseptic substance to prevent mildew, whereas heavily sized cloth invariably contains chloride of zinc. This is usually taken into consideration in the taping, as it is well known that "pure" sized yarns must be more thoroughly dried than heavily sized yarns.

The practice of making a "pure" mixing on the remnants of one containing chloride of magnesium also gives rise to a damage previously mentioned; *i.e.* tendering during the singeing operation in bleaching. The first mixing in such a case may contain

o

sufficient chloride of magnesium to cause most serious damage, especially if the sow box has not been well cleaned out, and the flannel covered roller not well washed. It looks a small matter to neglect, and manufacturers are surprised when they learn that tendering has occurred after the cloth has been singed. This matter is sufficiently important that if it be found impossible to thoroughly clean out a size beck for "pure" mixings, a separate beck should be used, and kept for that purpose only.

Chloride of magnesium, used in the form of a strong solution, has the power of converting starch into a very adhesive mass on boiling. This effect is also produced when a strong solution of chloride of zinc, or a strong solution of chloride of calcium is boiled with starch. Many sizing compounds have been placed upon the market which consist of farina boiled with one or other of the foregoing substances. They have a certain merit, but it might pay the sizer to manufacture them himself. The additional adhesiveness given to starch by boiling with strong solutions of the foregoing substances is not obtained if very dilute solutions are boiled with the starch.

CHLORIDE OF CALCIUM.

Chloride of calcium is occasionally used in sizing. It is a bye-product produced in many chemical works, especially in bleaching powder works where

chlorinated lime is produced by the Weldon's process. It may also be manufactured by neutralising hydrochloric acid with carbonate of calcium (ordinary chalk or limestone).

Chloride of calcium manufactured by either of the above methods generally contains impurities, such as salts of iron, free acid, and not infrequently, when manufactured by the Weldon's process, hypochlorite of calcium. Unless these substances are removed they may cause serious damage.

Chloride of calcium must not be used as a softener in conjunction with any of the sulphates, such as Epsom or Glauber's salts. As previously stated, on page 161, these substances undergo decomposition when they come in contact with chloride of calcium.

Chloride of calcium is not so readily decomposed on heating as chloride of magnesium. It might on this account be used, with less fear of damage, for goods intended for bleaching. At the same time it is advisable to keep it out of any mixing where it is known the cloth has afterwards to be bleached.

Chloride of calcium should never be used in sizing without being systematically analysed for the impurities previously mentioned. The following tests should be applied to every consignment obtained from the dealers:—

FREE ACID.—The sample should be tested for free acid by means of blue litmus paper, as described on page 34. If acid be shown to

be present it should on no account be used, as it might not only spoil the mixing by converting the starchy matter into dextrin during the boiling operation, but it might also give rise to iron-stains when the yarn reached the looms. If a large quantity of the starchy matter became converted into dextrin, in a heavy mixing, it would be impossible to get the right weight of size on the yarn, as the size would dust off in the process of weaving, and probably cause "soft beams."

CHLORIDE OF IRON.—The sample should be carefully tested for iron by means of a solution of ferrocyanide of potassium. If a blue colour be produced it should not be used unless passed as safe by an expert, and if a blue precipitate be produced on the addition of the ferrocyanide of potassium, it should be rejected without hesitation, as such a sample—and many such are sold to sizers—would most certainly give rise to iron-stains in the woven cloth.

HYPOCHLORITE OF CALCIUM.—Hypochlorite of calcium has been found in many samples of chloride of calcium sold to sizers. It is a most dangerous impurity, for although it may be successfully employed in converting starch into a soluble form of starch, if rightly used, it may, if its presence be not known, cause serious damage by thinning the size to such an extent as to cause "soft beams." In mixing heavy size it is usual to boil the chloride of calcium

along with the China clay in an iron pan. If hypochlorite of calcium be present it will attack the iron, and sufficient may be brought into solution to cause iron-stains. Such a case came under the writer's notice some time ago. In this case the solution of chloride of calcium was so charged with hypochlorite of calcium that free chlorine was given off when it was boiled with the clay. The iron of the pan was attacked to such an extent that the clay was coloured brown. Had this gone into the mixing unnoticed the cloth sized with it would have been spoiled.

The presence of hypochlorite of calcium may be detected by adding a few drops of *dilute* hydrochloric acid to the solution, in a test tube, and gently warming. No odour of chlorine should be shown by this test. If chlorine be shown to be present, the sample should not be used. A further test might be made by adding a small quantity of a solution of iodide of potassium to the suspected solution, and afterwards a small quantity of thin starch paste. If chlorine be liberated on the addition of *very dilute* acid, it will decompose the iodide of potassium, liberating free iodine. This latter substance, in contact with the starch, will show a deep blue colour.

GLYCERIN.

Glycerin is produced in large quantities in the operation of manufacturing soap. At one time it

was considered a waste product, and was thrown away with the spent lye. To-day it is of more value than the soap itself. Glycerin is also manufactured by passing super-heated steam through oils and fats, and by this method large quantities of glycerin are now obtained.

Pure glycerin should have a specific gravity of 1.261, and it should not leave any ash when burnt in a platinum crucible over the Bunsen's flame. The absence of ash shows the absence of mineral impurities, or mineral adulterants.

Crude commercial glycerin, as sold for sizing purposes, generally contains 80 per cent of real glycerin, 10 per cent. of mineral matter (the chief portion of which is common salt), and 10 per cent. of water and organic matter. Commercial glycerin containing 80 per cent. of real glycerin is suitable for sizing purposes.

Glycerin is frequently adulterated with chloride of magnesium, chloride of calcium, and glucose. It should, therefore, be always tested for these substances. The tests may be made as follows:—

PERCENTAGE OF ASH.—This is determined by burning a weighed portion of glycerin in a platinum crucible, and weighing the resultant ash. If free from ash, mineral adulterants cannot be present. The burning should be conducted at as low a temperature as possible, otherwise chloride of sodium, if present, will be partially volatilised. If glucose

be present it may be detected during the burning process by the characteristic smell of burnt sugar, and by the amount of carbonisation which takes place.

CALCIUM AND MAGNESIUM.—A few drops of ammonia, and an excess of chloride of ammonium should be added to a solution of the glycerin, and afterwards a solution of oxalate of ammonium. A white precipitate is formed if calcium be present and no precipitate is formed if the sample be free from calcium. If calcium be found, an excess of oxalate of ammonium must be added to precipitate the whole of it, and the liquid filtered. The filtrate is tested for magnesium by adding an excess of solution of ammonia and a solution of phosphate of ammonium. A white granular precipitate is formed if magnesium be present. Another portion of the glycerin should be dissolved in distilled water and tested for hydrochloric acid (chlorides) by adding a few drops of nitric acid and nitrate of silver. A white curdy precipitate is produced if chlorides be present. (Crude glycerin will always show the presence of chlorides, on account of the chloride of sodium which is invariably present, but pure glycerin should be free).

GLUCOSE.—Glucose may be detected in glycerin by boiling a portion with Fehling's solution. A red precipitate of cuprous oxide is formed if glucose be present. This test must be made with care as

glycerin will decompose Fehling's solution if the boiling is prolonged. Crude commercial glycerin always shows the reaction for glucose.

Crude commercial glycerin has a specific gravity of about 1.30, and it should be free from glucose and the chlorides of calcium and magnesium.

USE OF GLYCERIN IN SIZING.

Glycerin is a very hygroscopic substance, and on this account may be used to advantage in "pure" sizing for the purpose of improving the weaving. This is especially so where the goods have to be bleached. It possesses none of the objectionable features of chloride of magnesium or chloride of calcium. The chief objection to its use is its high price. If glycerin be used in "pure" sizing, for goods which are intended to be sold in the grey state, it will be advisable to use a little salicylic acid in the mixing. This will prevent the formation of mildew, a danger to be feared wherever deliquescent substances are used in "pure" sizing. This matter is further discussed under salicylic acid.

GLYCERIN SUBSTITUTES.

Substances are often sold as "glycerin substitutes" or "glycerin softeners" to manufacturers. They rarely contain any glycerin at all, being generally mixtures of chloride of magnesium, glucose, and water, or chloride of calcium, glucose

and water, and sometimes mixtures containing equal volumes of chloride of zinc and chloride of magnesium. They are possibly useful, but the price charged for them is very much higher than the actual value of the components of the mixture.

The following analyses give the composition of three of these glycerin substitutes:—

	No. 1 per cent.	No. 2 per cent.	No. 3 per cent.
Chloride of Magnesium ...	30 ...	40 ...	14'02
Chloride of Zinc	— ...	— ...	25'76
Glucose	4'5 ...	4'0 ...	—
Water	92'5 ...	92'0 ...	60'22
	<hr/> 100'0 <hr/>	<hr/> 100'0 <hr/>	<hr/> 100'00 <hr/>

The glycerin substitute marked No. 3 was sold by the dealer at 12/6 per cwt. Its value was under 5/- per cwt. The writer has come across cases where as much as 25/- per cwt. has been charged for a similar preparation. It could have been made by the manufacturer by mixing together equal volumes of chloride of zinc solution at 102° T. and chloride of magnesium solution at 56° T.

GLUCOSE.

This substance is sometimes used for sizing, but more often for “finishing” cotton goods. It is hardly a “softener” in the true sense, as it may also be employed to give a hard feel to cloth or yarn. Its effect may be varied according to the manner in

which it is dried on the yarns, and according to the presence or absence of deliquescent substances in the size.

Glucose sugar is largely produced on the Continent and in America from starch. Chemically it is the same as the sugar found in grapes. The American glucose is manufactured almost entirely from maize starch, that on the Continent from farina. The process consists in boiling the starch with water and sulphuric acid, using about 2 per cent. of acid. This acid is finally neutralised with lime or chalk, which combines with the acid to form insoluble sulphate of calcium. The sugar liquor is separated, filtered, and afterwards evaporated *in vacuo* to a certain consistency to be sold as liquid glucose, or still further evaporated until it solidifies, when it is sold as glucose chips.

Glucose is more often used in sizing in the form of glycerin substitutes, than simply as glucose. It is a suitable medium for mildew development, and it has no special properties which make it valuable for sizing, although it has valuable properties as an ingredient for "finishing."

CHAPTER VI.

*Ingredients used for preserving Size
from Mildew.*

IT is necessary to use some substance for preserving size from mildew in all cases where deliquescent chemicals have been used as softening agents. No cloth is safe from mildew which contains such ingredients as chloride of magnesium or chloride of calcium, unless an antiseptic is used at the same time.

CHLORIDE OF ZINC.

Chloride of zinc is the most important antiseptic used in sizing cotton yarns. It is a compound of chlorine and zinc, and is prepared in several ways. The method generally employed is to dissolve zinc in hydrochloric acid. The solution takes place with a violent re-action, and large quantities of hydrogen gas are given off. The zinc very often contains arsenium as an impurity, and when this is the case, arseniuretted hydrogen is liberated along with the hydrogen. Arseniuretted hydrogen is one of the

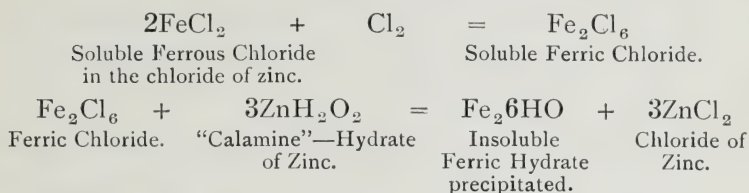
most powerful poisons known, and great care should be taken that the gaseous products are carried away from persons employed in the manufacture of chloride of zinc.

Chloride of zinc is also prepared from "calamine," a native carbonate of zinc. Hydrochloric acid is used as before, and carbonic acid gas (carbon dioxide), is given off.

When metallic zinc is used, it is generally in the form of spelter, or in the form of scrap zinc, collected from many sources. All forms of zinc contain numerous impurities. The most objectionable one from a sizer's point of view is iron. This metal is dissolved in the acid at the same time as the zinc, and remains in solution in the form of chloride of iron. It is absolutely necessary to remove this impurity from chloride of zinc, and if carefully manufactured, it can be obtained quite free from it. If chloride of iron be not removed, it will discolour the cloth by producing iron-stains.

The following is the usual method of removing iron salts from a solution of chloride of zinc:—Chlorine may be passed into the solution or it may be treated with chlorinated lime or chlorate of potash. These substances convert the iron from the ferrous to the ferric state. This operation is necessary because ferrous iron is not completely precipitated in the next stage, whereas ferric iron is completely precipitated. After adding one or other of the above oxidising

agents, lime, or better, “calamine” (the impure hydrato-carbonate of zinc previously mentioned) is added. This precipitates the ferric iron as ferric hydrate. The following equations will illustrate the re-action:—



Not the least of the advantages to be obtained from the use of “calamine,” or lime, for the purpose of precipitating iron salts is that these substances have the effect of neutralising any trace of free acid which may have been left in the chloride of zinc solution. The presence of small quantities of chloride of calcium in the finished product is due to the use of lime as the precipitating agent, and this must not be confused with chloride of calcium which may have been added as an adulterant.

Sometimes oxidation is allowed to take place by exposing the impure chloride of zinc to the atmosphere for a long period, but the method is slow and requires great storage.

After the chloride of zinc has been treated as above it is allowed to stand and settle. The clear solution is run off from the deposited iron precipitate, and, where necessary, this is evaporated down to a specific gravity varying from 1.46 to 1.52 or 92° to

104° Twaddell, in which form it is usually sold in this country. For shipment abroad it is further evaporated until it solidifies. In this state it costs less for freight charges, because the payment of carriage on water is avoided.

With the exception of tallow and soap, chloride of zinc is one of the most expensive of the ordinary ingredients of size. As previously stated, it is generally sold in solution in this country. The liquid is more convenient to handle than the solid, but it lends itself more open to adulteration. The consequences of adulteration may be far more serious with this substance than with any of the others. Within the writer's own knowledge, many cases of mildew have been caused by using adulterated chloride of zinc. A peculiar case of adulteration came under notice a few years ago. A certain firm had been in the habit of buying chloride of zinc from *one agent* only for many years, for which they paid a very high price. On one occasion they ran short, and sent for a quantity from Messrs. Wm. Blythe & Co. Ltd., of Church, to put them on until they could get a consignment from their usual dealer. This was invoiced at £2 per ton less than they had been in the habit of paying. After using a considerable portion of the chloride of zinc from one cask it was found that the sized warps were different in "feel" than formerly. With a view to discover the cause of this the zinc was submitted

to analysis, and was found to be pure and of good quality. In questioning the manufacturer the writer found that he was using more than double the quantity of chloride of zinc necessary to keep the size from developing mildew. This quantity was the quantity laid down by the agent who had supplied them in the first instance. This being the case, the writer suggested making an analysis of a sample of the chloride of zinc they had been previously using. It was found to be grossly adulterated with common salt, and instead of containing from 44 to 46 per cent. of chloride of zinc, it contained only 14 per cent., and 33 per cent. of common salt. The cause of the difference in the feel of the yarns where a pure chloride of zinc was used was accounted for at once. In using the same quantity of the *pure article* they had been using a very large excess. It is a well-known fact that an excessive quantity of chloride of zinc does not improve the weaving.

The following substances are often found in commercial chloride of zinc, either as impurities or as adulterations :—

- (1) Chloride of Sodium (common salt).
- (2) Chloride of Iron.
- (3) Chloride of Calcium.
- (4) Chloride of Magnesium.
- (5) Chloride of Ammonium.
- (6) Sulphate of Soda (Glauber's salts).

In making the necessary tests, the following method of procedure should be followed :—

(1) The specific gravity should be taken as described on pages 26 and 27, either by means of the specific gravity bottle or by means of a suitable Twaddell's hydrometer.

The specific gravity test is useful but it is not sufficient to determine the purity of a sample of chloride of zinc. Two liquids, supposed to be chloride of zinc, may have the same specific gravity, or Twaddell, and one may be pure and the other impure. As a general rule, however, if it be found that the sample under examination is free from more than traces of impurities, and the specific gravity is high, it may be passed as pure, because it is impossible to get a high specific gravity with any substance likely to be used as an adulterant.

(2) COMMON SALT.—This substance is always found in chloride of zinc in greater or smaller quantities. The usual test for the presence of a sodium salt is made by means of the Bunsen's flame. A perfectly clean piece of platinum wire is dipped into hydrochloric acid and heated in the top part of the Bunsen's flame, until it ceases to give a yellow colour when placed at the edge of the lower part of the flame. The clean wire is then dipped into the chloride of zinc solution, or other substance to be tested, and the drop at the end of the wire is introduced into the flame. Sodium salts give an intensely yellow tint to a Bunsen's flame. This test, however, is no use at all for such a commercial

article as chloride of zinc, because traces of most impurities may be ignored unless they be of an injurious nature. The best test for the presence of common salt as an adulterant is the following, and should be conducted in a long narrow test tube:-- The test tube is filled one-third full with the solution of chloride of zinc. To this is added twice its bulk of strong hydrochloric acid, and the mixture well shaken up. If there be any excess of common salt, it will be precipitated on standing a few seconds. The salt may be filtered off and the hydrochloric acid removed by drying.

No adulterated samples of chloride of zinc would contain less than 1 per cent. of common salt, for the simple reason that it does not pay to adulterate in traces. The great value of this test is, that it passes over mere traces, and precipitates only quantities which have been added for purposes of adulteration. In all cases a sample of chloride of zinc should be condemned if salt be precipitated by this test. Another advantage of this test is, that the common salt is precipitated exactly in the same form as it was added to the chloride of zinc, no chemical change having taken place. It is possible, therefore, to confront the dealer with the actual evidence of his fraud. The test depends upon the fact that common salt is only slightly soluble in strong hydrochloric acid, although it is very soluble in water.

(3) CHLORIDE OF CALCIUM.—This substance is often found in small quantities in chloride of zinc, and its presence is generally due to the use of lime and chlorinated lime for the purpose of oxidising and precipitating the iron salts. It is also very often used as an adulterant.

Where chloride of calcium is present in such quantities as to warrant the assumption that it has been wilfully added to increase the profits of the seller it is very objectionable. It lessens the amount of actual chloride of zinc present in the solution and it is entirely opposite in its action. It has no anti-septic properties, but, on the contrary, it has a strong tendency to assist in the development of mildew growths on account of its power of absorbing moisture. It may also alter the character of the size if any of the sulphates, such as Glauber's or Epsom salts, are present in the mixing. The following is the best method of testing for the presence of chloride of calcium:—

A small portion of the sample is placed in a large test tube, and twice its bulk of water, and a little ammonium chloride solution added. Strong ammonia is then added drop by drop until the precipitate of hydrate of zinc first formed is dissolved. A solution of oxalate of ammonium is then added. The presence of calcium is shown by the formation of a white precipitate. If a slight cloudiness be produced, only a small trace of calcium can be present.

If the precipitate is bulky and quickly settles, it is probable that there is adulteration. In such a case the sample should be submitted to a trained analyst to determine the amount.

An important confirmatory test for the presence of calcium salts is to dip a clean platinum wire in hydrochloric acid, and take up a portion of the precipitate on the end of the moistened wire. This is introduced into the Bunsen's flame as in the sodium test. Calcium salts give a brick-red colouration to the flame not easily mistaken.

(4) CHLORIDE OF MAGNESIUM.—This salt is very often found in chloride of zinc, generally in small quantities as an impurity, but sometimes in large quantities as an adulterant. The filtrate from the precipitated oxalate of calcium in the previous test is examined for magnesium by adding a solution of ammonia and a solution of phosphate of sodium. A white granular precipitate will be at once formed if magnesium salts are present. No notice should be taken of a precipitate which forms on standing some time. This latter precipitate is from the zinc itself. In accurate work it is necessary to remove the zinc before testing for either calcium or magnesium.

(5) TEST FOR SULPHATES.—The presence of such salts as magnesium and sodium sulphates may be detected by adding water and hydrochloric acid to the solution of chloride of zinc contained in a test

tube, and, after shaking up, a few drops of barium chloride solution. A heavy white precipitate is formed if sulphates be present.

In this test care should be taken not to add too much strong hydrochloric acid, as this substance precipitates chloride of barium from solution, just as in the case of common salt. The precipitate if formed, however, is soluble in excess of water, and is readily distinguished by this means from the sulphate of barium. If there be a heavy precipitate of sulphate of barium, it may be that there are both magnesium and sodium sulphates present. If, in the previous tests, magnesium salts were shown to be absent, then the sulphate will be sulphate of sodium only.

(6) CHLORIDE OF AMMONIUM.—This substance is almost invariably present in chloride of zinc as an impurity. It is easily detected by adding a small quantity of the zinc solution to an excess of solution of caustic soda in a test tube, and gently boiling. Ammonia, in the form of gas, will be driven off, and may be recognised by the characteristic smell of that substance. Traces may be detected by holding a piece of wet red litmus paper at the mouth of the test tube, taking care that the liquid in the tube does not touch it. The litmus paper is turned blue if ammonia be present. Chloride of ammonium is never wilfully used as an adulterant in chloride of zinc on account of its high price.

OBJECTIONABLE IMPURITIES.

Under this heading will be described those impurities which are due either to the zinc or to the acid from which the chloride of zinc is prepared, or to a faulty method of manufacture. These impurities are in no sense adulterants, their presence being purely accidental. Notwithstanding this, if they be present, they will cause serious damage to the cloth.

(1) IRON SALTS.—The presence of iron salts is objectionable in all substances used for sizing. The tests for iron are so delicate, however, that they are often misleading unless carried out by an expert.

In testing chloride of zinc for iron the solution should be treated as follows:—A sample is placed in a large test glass, or beaker, and exposed to the air for a few days, care being taken to avoid contamination with dust. Any large quantities of iron, which should have been removed before the zinc was put on the market, will be shown by the formation of a brownish red precipitate. Chloride of zinc depositing iron in this way should *never* be used for sizing.

Where iron exists in traces only it is necessary to employ a much more delicate test, and for this purpose ferrocyanide of potassium, or sulphocyanide of potassium, may be used. Ferrocyanide of potassium gives a blue colouration, or a blue precipitate, according to the amount of iron present, whilst

sulphocyanide of potassium gives a blood red colouration with soluble ferric salts in the presence of nitric acid. Ferrocyanide of potassium produces a white precipitate with zinc salts, and the blue colour may be masked if the test be not carefully performed.

A solution of logwood gives a pink colour with pure chloride of zinc solution, but in the presence of iron the colour is changed to dark blue.

A good test for the presence of iron in chloride of zinc is made by adding an excess of ammonia to the diluted solution of zinc, and then a solution of sulphide of ammonium. If the sample be free from iron a white, or yellowish white, precipitate of sulphide of zinc will be formed, but if iron be present the precipitate will be dark in colour. The presence of lead will also darken the precipitate, and this may be mistaken for iron. If, therefore, a dark coloured precipitate be formed, another portion of the zinc must be acidified with hydrochloric acid, and sulphuretted hydrogen gas passed through the solution. Lead, if present, is precipitated, or the solution is darkened by this test. After filtering, the solution should be rendered alkaline with a solution of ammonia. If iron be present it will be precipitated as sulphide in the alkaline solution.

The authors find that most samples of chloride of zinc manufactured at the present time are practically free from iron. More care is exercised in the

production of this substance than was formerly the case. Occasionally a sample is found containing an outrageous quantity of chloride of iron. One such sample is shown on page 253. This sample contained 6.01 per cent. of chloride of iron, and when boiled in contact with yarn in the sow-box of the tape frame oxide of iron was actually precipitated in sufficient quantity to colour the size red. A solution such as the fore-going could not fail to be noticed, by anyone used to solutions of chloride of zinc, on account of the green tint always present when an excessive amount of chloride of iron is present.

(2) FREE ACID.—Free acid is another objectionable substance sometimes found in chloride of zinc. The test for acid, by means of litmus paper, requires carefully conducting as chloride of zinc itself will turn blue litmus paper red. In the case of chloride of zinc free from acid the change is gradual, but if the litmus paper becomes red at once the zinc should be rejected. A better test is made by adding a drop of dilute methyl orange solution to a *diluted* solution of zinc. If acid be present it will be shown by the production of a pink colouration.

The objection to free hydrochloric acid in such substances as chloride of zinc has already been discussed under chloride of magnesium and chloride of calcium on pages 222 and 228. It may weaken the size and tender the cloth, and it is almost

certain to produce iron-stains where the yarn comes into contact with the iron of the looms.

(3) LEAD (Chloride of lead).—This substance is frequently found in chloride of zinc. Its presence may be shown by passing sulphuretted hydrogen gas through the acidified solution, as previously described. If lead be present a black or brownish precipitate will be formed. If a trace only be present the liquid is discoloured.

ANALYSIS OF CHLORIDE OF ZINC.

The value of a sample of chloride of zinc to the sizer is determined by the amount of actual chloride of zinc present, if objectionable impurities, such as acid or iron salts, are absent. Samples showing a high specific gravity or Twaddell are almost always free from adulteration, but they are not necessarily free from injurious impurities. As a matter of fact it is impossible to get sufficient of any adulterant, such as the chlorides of calcium, magnesium, or sodium, into solution, which will give the necessary high specific gravity at which chloride of zinc is usually sold.

The manufacturer should know how to determine the amount of actual chloride of zinc present in the sample he is using. Two methods are available, the first by volumetric analysis, and the second, by gravimetric analysis.

The following volumetric estimation (Fahlberg and Maxwell Lyte) has been found useful by the

authors. The method is not available in the presence of iron, but as most samples of chloride of zinc sold to sizers are practically free from this substance the process may be used nine times out of ten without any previous preparation of the chloride of zinc. If iron be found to be present in the preliminary tests it must be removed as follows :—

The zinc should be acidified with hydrochloric acid and boiled. Whilst boiling, a little chlorate of potash or strong nitric acid should be added to oxidise any ferrous iron to the ferric state. The solution is then treated with ammonia in excess, and filtered. The filtrate contains the zinc in solution in the excess of ammonia. The precipitated ferric hydrate is washed with dilute ammonia, and the washings collected and added to the zinc filtrate. A small amount of zinc is always carried down with the ferric hydrate. This precipitate should therefore be dissolved in hydrochloric acid, and re-precipitated with excess of ammonia as before, filtrered, and the filtrate collected in the zinc solution. To the solution hydrochloric acid is added in excess, and brought to the boiling point. This is then titrated with standard ferrocyanide of potassium, as described hereafter, using uranium nitrate as the indicator.

SOLUTIONS REQUIRED.

(1) A standard solution of ferrocyanide of potassium of such a strength that 1 c.c. = 0.01 gramme of zinc.

(2) A standard solution of zinc, made by dissolving 10 grammes of pure metallic zinc in hydrochloric acid and diluting to 1 litre=(1,000 cubic centimeters). Each c.c. of this solution will contain 0.01 gramme of zinc.

(3) A solution of uranium nitrate.

THE ANALYTICAL PROCESS.—A beaker is carefully weighed on the balance and about 1 gramme of the chloride of zinc to be estimated added, and carefully weighed. The difference in weight gives the amount of zinc taken. This is freely acidified with hydrochloric acid, and heated to the boiling point, two or three drops of uranic solution added, and the ferrocyanide delivered into the solution from a stoppered burette. White ferrocyanide of zinc is precipitated, and, as the drops of ferrocyanide fall into the solution, a brown spot of ferrocyanide of uranium appears, but disappears again on stirring so long as free zinc exists in solution. The moment all the zinc is converted into ferrocyanide the addition of the test solution tints the whole liquid brown. Before this point is reached, and as the brown spot disappears more slowly, a porcelain plate should be placed by the side of the operator. A number of spots of uranium nitrate solution are dropped on the plate from a glass rod. A drop of the mixture is taken from the beaker by means of a glass rod, and brought into contact with one of the uranic spots. If no brown colour be produced the

ferrocyanide is added drop by drop until the mixture in the beaker produces a brown tint on coming in contact with one of the spots of uranium nitrate solution. It is necessary to make a blank test with the standard zinc solution and standard ferrocyanide of potassium solution before commencing the analysis of a sample of chloride of zinc, and when the shade of colour produced in the actual analysis of the chloride of zinc is the same as in the titration of the standard zinc solution, the process is ended.

The number of c.c. of ferrocyanide solution used is multiplied by 0.01. This gives the amount of metallic zinc in the solution, which should be calculated to chloride. Each 65 parts by weight of zinc is equivalent to 136 parts by weight of chloride of zinc. The amount of chloride of zinc found in the weight of solution taken is calculated to a percentage.

The gravimetric process is carried out as follows:—A weighed quantity of the solution of chloride of zinc is diluted with water and acidified with hydrochloric acid in a beaker, then boiled. Nitric acid is added to convert ferrous iron (if present) into ferric. Excess of ammonia and chloride of ammonium are added to precipitate the ferric hydrate, and sufficient to dissolve the hydrate of zinc. The mixture is filtered, and washed with ammonia and water, and the washings added to the solution of zinc. The precipitate is re-dissolved in

hydrochloric acid, and re-precipitated as directed in the volumetric estimation. The mixed filtrates are treated with an excess of solution of sulphide of ammonium. The liquid is set aside for some hours and then filtered through a filter paper, the amount of ash of which is known. The precipitate is thoroughly washed with dilute solution of sulphide of ammonium, dried, and transferred to a weighed crucible and ignited for some time at a bright red heat. The filter paper is rolled up and wrapped round with a piece of platinum wire so as to form a cage, and burnt to a white ash in the Bunsen's flame. The ash is added to the crucible and the whole ignited. The crucible and contents are cooled and weighed, and from the oxide of zinc found, the weight of the filter paper ash is deducted. The oxide is calculated to chloride, and the chloride to a percentage of the weight of chloride of zinc originally taken.

N.B.—Care must be taken that the sulphide of zinc is removed (after drying) from the filter paper without detaching any of the paper, otherwise, as the paper carbonises when heated in the crucible, a portion of the oxide of zinc formed will be converted into metallic zinc, and so lost by volatilization. It is better to ignite in the presence of nitrate of ammonium.

The following table, marked No. 1, shows the composition of commercial chlorides of zinc of good average quality which have been analysed at

various times by the writer. The table marked No. 2 shows the composition of some adulterated samples, except in the case of No. 4. This latter sample was badly prepared, and it contained an excessive and dangerous quantity of chloride of iron.

TABLE NO. 1.

	No. 1. per cent.	No. 2. per cent.	No. 3. per cent.	No. 4. per cent.
Chloride of zinc	41·644	43·77	45·44	45·74
Chloride of calcium	1·378	1·87	·37	trace
Chloride of Magnesium ...	trace	.....	·76	0·74
Chloride of iron .....	.....	.....	.....	.....
Chloride of sodium	1·470	1·24	1·04	0·97
Water	55·508	53·12	52·39	52·55
	100·000	100 00	100·00	100·00
Specific gravity	1·46	1·49	1·52	1·518
Equal to degrees Twaddell	92°T	98°T	104°T	103·6°T

The above table should be compared with the one below. The solutions in Table No. 2 have been submitted to the writer at various times, as pure samples of chloride of zinc, but on analysis they have been found to be adulterated.

TABLE NO. 2.

	No. 1. per cent.	No. 2. per cent.	No. 3. per cent.	No. 4. per cent.
Chloride of zinc	31·31	18·43	33·74	40·04
Chloride of calcium	0·78	11·78	0·79	1·12
Chloride of magnesium...	trace	trace	13·12	.....
Chloride of iron .....	.....	trace	.....	6·01
Chloride of sodium	11·37	12·17	0·78	0·67
Water	56·54	57·62	51·57	52·16
	100·00	100·00	100·00	100·00

Apparently the amount of adulteration in the first case is 11 per cent., but it is really very much more. Pure chloride of zinc solution contains about 45 per cent. of the solid chloride, so that the actual adulteration is about 26 per cent.

USE OF CHLORIDE OF ZINC IN SIZING.

A great difference of opinion exists amongst manufacturers as to the best method of using chloride of zinc or other antiseptics. It should be remembered that the best results are always obtained by bringing into the closest contact those substances likely to mildew, or decompose, with those substances which are being used to preserve them. It is not necessary to preserve mineral matter such as China clay from mildew, so it is no advantage to boil the zinc with the clay, as is very often done. The proper method of procedure is to add the chloride of zinc, or other antiseptic, to the flour, the substance which will mildew, and let them stay in contact as long as convenient. The other ingredients of the size merely dilute the chloride of zinc, and thus dilute its antiseptic powers. This matter is further discussed in the following chapter on size mixing.

By careful experiments it has been found that 8 per cent. of real chloride of zinc (solid) to the starch or flour used, or $3\frac{1}{2}$ to 4 gallons of good chloride of zinc to each sack of flour (280 lbs.) is sufficient to

preserve it from mildew under any ordinary conditions. It must be remembered that this proportion is sufficient where the warps are run reasonably dry, and where the cloth is afterwards kept from getting excessively damp, but it is not sufficient if the cloth be treated to extraordinary usage. Such a percentage of chloride of zinc is not certain to preserve a cloth from mildew if it be allowed to get wet and is afterwards packed damp, and the authors have considerable doubts as to the preserving power of any excessive quantity of chloride of zinc in such circumstances.

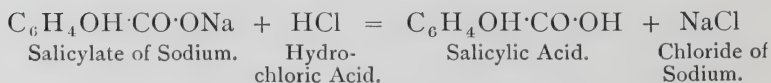
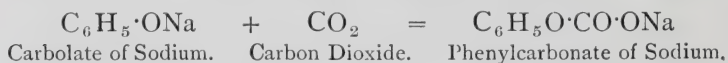
Other substances are used occasionally as antiseptics for size, but unless there is a special stipulation against the use of chloride of zinc, as instanced by goods intended to be bleached, it is by far the most suitable antiseptic for sizing purposes generally. The cost is low and the results definite. Moreover in medium and heavy sizing it has one special advantage; it assists in getting the necessary weight. This is a matter of considerable importance in heavy sizing.

It may be advisable to warn manufacturers once more at this stage against the use of secret preparations. Many cases of damage to fabrics which have been singed are traceable to the use of secret preparations which have contained chloride of zinc and chloride of magnesium. The manufacturer is unaware that he is using such chemicals in his size,

and his surprise is generally very great indeed when he has the responsibility for the damage placed upon him.

SALICYLIC ACID— $C_6H_4OH \cdot CO \cdot OH$.

Salicylic acid occurs in the form of white crystals, and it is one of the most powerful antiseptics known. It is prepared by acting upon pure carbolic acid (phenol) with carbon dioxide. The carbolic acid is first saturated with caustic soda. This converts the carbolic acid into sodium-phenol or carbolate of sodium, $C_6H_5 \cdot ONa$. The carbolate of sodium is then saturated with carbon dioxide at the ordinary temperature, by which phenylcarbonate of sodium is produced. The latter substance is converted into salicylate of sodium on gradually heating in closed vessels to a temperature of 450° Fah. The salicylate of sodium is converted into salicylic acid by the action of hydrochloric acid, and further purified by recrystallisation from alcohol. The following equations will illustrate the chemical changes which occur in the process of manufacture:—



USE OF SALICYLIC ACID IN SIZING.

Salicylic acid is a useful antiseptic, but until recent years it has been too costly to be used in sizing. The price is much lower at the present time, and, as an antiseptic for "pure" sized yarns, in which chloride of magnesium or chloride of calcium *are not* ingredients of the size, it cannot be surpassed. Although an acid it has no objectionable features, and it is as effective as chloride of zinc in its antiseptic properties for "pure" sizing. Considering the amount of this substance which is required to prevent mildew growths, it is as cheap as chloride of zinc. Six ounces of salicylic acid, to each 100 pounds of starch, are sufficient to prevent mildew under ordinary conditions. When wheaten flour is used it will be advisable to use eight ounces, as flour has a greater tendency to generate mildew than the pure starches.

Salicylic acid is only slightly soluble in cold water, but it is readily soluble in boiling water. On this account it is necessary to first dissolve the acid in boiling water, and add the solution formed to the size mixing.

When salicylic acid is used as an antiseptic in "pure" sized yarns for goods which are intended to be sold in the grey state, it is possible to employ glycerine in the size. As previously stated, glycerine has a powerful tendency to absorb moisture, and on this account the yarn is very considerably

strengthened, and the weaving considerably improved. It would not be advisable to employ glycerin without salicylic acid for such goods, as it might be the means of developing mildew.

It may be as well to state here that salicylic acid loses its antiseptic properties if free caustic alkali, such as caustic soda, or caustic potash, be an ingredient of the size.

THYMOL.

This powerful antiseptic is a camphor obtained from thyme oil, and horsemint oil. It is extracted by agitating the oil with a solution of caustic soda. The aqueous layer is separated and treated with an excess of dilute hydrochloric acid when thymol separates out as an oily layer. It may be obtained from the oil by submitting it to a low temperature when the thymol crystallises out.

Thymol is very slightly soluble in water, 1 pound requiring about 1,200 pounds of water to completely dissolve it. A delicate test for thymol consists in heating the solution with half its measure of glacial acetic acid, and its own measure of concentrated sulphuric acid. A fine violet-red colouration is produced which is not destroyed by boiling.

The only draw-back to the use of thymol in "pure" sizing is its price, otherwise it leaves nothing to be desired.

CARBOLIC ACID—PHENOL (C_6H_5OH).

This substance is a powerful antiseptic which is occasionally used in sizing. The only objectionable feature it possesses is its powerful odour. Carbolic acid is obtained from coal tar by fractional distillation. It is contained in that portion which distils over between 300° and 390° Fah. The product of distillation is treated with caustic soda. This alkali dissolves the carbolic acid, together with a certain amount of naphthalene. The alkaline solution is purified by a treatment with sulphuric acid which liberates the carbolic acid. This is further purified by again treating with caustic soda and afterwards with sulphuric acid. The oily liquid thus obtained is then distilled, that portion passing over into the receiver at a temperature of 360° Fah., being subjected to a freezing mixture. By this treatment the carbolic acid crystallises out, and is separated from the mother liquor by means of a centrifugal machine. The product may be further purified by a repetition of the processes.

Pure carbolic acid is a colourless solid, soluble in water to the extent of 1 part in 1,200. 5 to 10 per cent. of water liquefies the acid, which will then dissolve about 30 per cent. more water. The acid is soluble in alcohol, ether, glacial acetic acid, and glycerin.

Commercial carbolic acid almost invariably turns red when exposed to light. For sizing purposes

pure carbolic acid is not used, the variety known as No. 5 carbolic acid being generally employed. It is as actively antiseptic as the pure acid. The No. 5 carbolic acid consists largely of cresylic acid. Crude carbolic acid has a specific gravity of 1.05 to 1.065 at a temperature of 60° Fah. Carbolic acid is frequently adulterated, the principal substances used being water and tar oils. Neither of these substances has antiseptic value. The antiseptic value of different samples of carbolic acid may be ascertained by making samples of flour paste, using in each case the same quantity of flour and water. To each paste is added a certain proportion of the carbolic acid under examination and after this has been well stirred into the mass, the mixture is poured on plates, so that a surface, as large as possible, may be exposed to the air. The samples are allowed to stand, and should be examined each day. The one first showing signs of mildew is the weakest in antiseptic value. A suitable flour paste may be made by mixing 10 grammes of flour with 100 c.c. of water and heating as described on page 55.

CRESYLIC ACID.—CRESOL.

Cresylic acid is obtained from coal tar. It is that portion left in the retort after the carbolic acid has distilled over. Cresylic acid closely resembles carbolic acid in its properties, but it is a liquid whereas

carbolic acid is a solid. It is less soluble in water and boils at a higher temperature than carbolic acid. Like carbolic acid, the only objection to its use as an antiseptic for sizing purposes is the strong odour, similar to that of carbolic acid, which it possesses. It is a more powerful antiseptic than chloride of zinc,

Neither carbolic nor cresylic acids have the usual properties of ordinary acids, and they are in no way objectionable substances to use where coloured goods are being treated.

For the purpose of preventing mildew in sized goods, 10 ounces of either carbolic or cresylic acid should be used to each 100 pounds of starch.

CHAPTER VII.

*Size Mixings,
and the Methods and Plant employed
in Mixing Size.*

CLASSIFICATION OF SIZING.

BEFORE describing the plant used in mixing size, and before dealing with the operations involved in sizing, it will be necessary to discuss the principal objects for which sizing is carried out.

Originally sizing was carried out with the sole object of giving the yarn sufficient strength to enable it to be successfully woven into cloth. At the present time sizing is carried out with a great number of objects, not the least important of which is the production of a certain desired "feel" in the cloth.

For the sake of convenience in description sizing may be classified under four heads, viz.:—
"Pure" Sizing; "Light" Sizing; "Medium" Sizing; and "Heavy" Sizing.

“PURE” SIZING.—In “pure” sizing the main object is to give the yarn sufficient strength to withstand the friction of the healds and reeds during the process of weaving, without increasing the weight of the cloth unnecessarily.

A large proportion of “pure” sized goods are intended for bleaching. In many cases the goods have to be dyed or printed after this operation. The operations involved in bleaching remove the whole of the size from the cloth. On this account it is advisable to put as small a quantity of size on the yarn as is consistent with good weaving. Any excess of size is not only an increase in the cost of sizing, but it renders the cloth more expensive to bleach, on account of the extra boiling and washing required. Under no circumstance should chloride of magnesium, paraffin wax, or tallow adulterated with mineral oil or other unsaponifiable substance be used as an ingredient of size if the goods are intended to be bleached.

Size for a “pure” mixing is usually composed of starchy substances of some description, with fatty matter, and water. Such mixtures are usually prepared from either flour, farina, sago, or a combination of such starches as farina and sago, together with a sufficient amount of some “softener,” such as tallow, soap, or wax. The effect of the “softener” is to render the yarn pliable and so assist the weaving. Chloride of zinc is *sometimes* added to

“pure” size in order to prevent the formation of mildew in cloth which is intended for shipment in the grey state. Salicylic acid is also being used for this purpose, as stated on page 257.

It may be taken as a rule that “pure” size should be free from China clay and chloride of magnesium. Occasionally China clay is employed in “pure” size to increase the pliability of the yarn. This is not necessary, as a similar result could be obtained without China clay if an increased quantity of tallow were used in the mixing. The proportion of tallow or wax should also be small in comparison with the proportion of starchy matter, because, although a right proportion of these softeners make the yarn pliable, an excessive amount has a tendency to make the size friable. This has the effect of causing the size to rub off in the healds and reeds.

The substances used for “pure” sizing vary considerably in different districts for the same class of cloth. In certain districts there seems to be a desire to use as many ingredients as possible. It is not unusual to find a “mixing” containing farina, sago, Irish moss, tallow, paraffin wax, spermaceti, castile soap, white soap, gum tragacanth, and bi-carbonate of soda. Why all these ingredients are used, or what there is to be gained by such a conglomeration of substances, is a mystery which would probably puzzle the users to explain,

Quite as good results are obtained in other districts with less trouble and greater economy by using a mixture of say, sago and farina, with either tallow or paraffin wax.

At some future date, when sizing is better understood, these complicated mixtures, and the various nostrums at present used in "pure" sizing, will be replaced by simpler and more economical "mixings." The only losers by the change will be the vendors.

"LIGHT" SIZING.—"Light" sizing is generally understood to mean that in which the twist is weighted to the extent of from about 20 to 30 per cent. Such a weight can be obtained by the use of a "mixing" consisting of flour, tallow, and water only, see page 73. As a general rule, however, a "mixing" for "light" sizing will contain all the ingredients used for "medium" and "heavy" size, but in different proportions. It will be found that as "mixings" increase in strength, the percentage of China clay, chloride of magnesium, and tallow increases, whilst the percentage of starchy matter decreases.

"MEDIUM" SIZING.—In "medium" sizing the object is not only to put sufficient size on the yarn to enable it to resist the rubbing of the healds and reeds, but it is carried out with the object of adding weight to the cloth, together with the production of a certain "feel." This "feel" is quite as important

as the weight in many cases. The constituents of the size for "medium" sizing are usually water, starchy matter, China clay, chloride of magnesium, tallow, and chloride of zinc.

"HEAVY" SIZING.—This form of sizing is carried out with the object of introducing a very large amount of size into the cloth. This is done in order to give the cloth a better and fuller appearance than it would be possible to give with the same monetary value in cotton alone. Size for this class of work is composed of ingredients similar to those used in "medium" sizing, but the proportions are altogether different.

In "heavy" and more particularly in very "heavy" sizing, the yarn must be taken into consideration as well as the sizing ingredients. At the present time ring spun yarn is largely superseding mule spun yarn for "pure" and "light" sizing, but it is much more difficult to heavily size ring yarn to the same extent as mule yarn. This is owing to the fact that ring yarn is harder spun than mule yarn. The extra number of turns of twist per inch in this yarn reduce the interstices between the fibres of which the thread is composed. There is, therefore, less space to be filled up with size. On account of this difference in spinning the diameter of a thread, for the same counts, will also be less with ring yarn than it is with mule yarn. This means that there is less outside surface in ring

spun yarns to put the "size" on. The difference in the interstices between the fibres, and the difference in the diameters of ring spun yarn and mule spun yarn, may be small, but they also make a great deal of difference in the results in "heavy" sizing. It must be remembered that the ingredients used in size are mostly insoluble substances, and, as such, they cannot *enter into* the fibres forming the thread, but are *simply pressed on the surface, and into the spaces between the fibres*. This being so, it must follow that those yarns which are known as "soft spun" yarns, on account of their having a less number of turns per inch, and which are therefore not so tightly spun, are the best for "heavy" sizing.

ARRANGEMENT OF PLANT IN SIZE MIXING ROOMS.

The arrangement of the size mixing apparatus and the number of becks and pans required for a given number of looms depends, to a great extent, upon the class of cloth it is intended to produce. In a mill where only "pure" sizing is carried out the plant required is small as compared with a mill in which a large variety of sized goods are manufactured. For "pure" sizing, unless flour is one of the ingredients of the size, one or two small becks will be ample. If flour be used it will be necessary to have at least two additional becks, one to be used

for fermenting or for steeping the flour, whilst the other should be used to store the prepared flour.

For "medium" and "heavy" sizing a clay pan and a beck for the chloride of magnesium will be required. If it be intended to use a variety of "mixings" it will be necessary to have a number of extra becks in which the various strengths of size may be stored.

A detailed description of the construction of the size becks is unnecessary in a book of this kind, and the practical man should be fully conversant with them. At the same time a few words in regard to the arrangement of the apparatus may serve a useful purpose. Unfortunately in many of the older types of mills the plant has been arranged more with a view to utilising the space at the manufacturers disposal than with the object of enabling the size-mixer to perform his work with as little labour as possible. Haphazard arrangement of this kind generally necessitates manual labour for the purpose of lifting and carrying the whole of the sizing ingredients to the different becks and pans. Under such conditions the floors of the rooms and the sides of the "mixing" becks become covered with an accumulation of the ingredients used in the size. Such conditions are not conducive to either cleanliness or to economy. The plant in all modern size-mixing rooms, whether the rooms are built on the ground floor or contained in a two-storied building, should

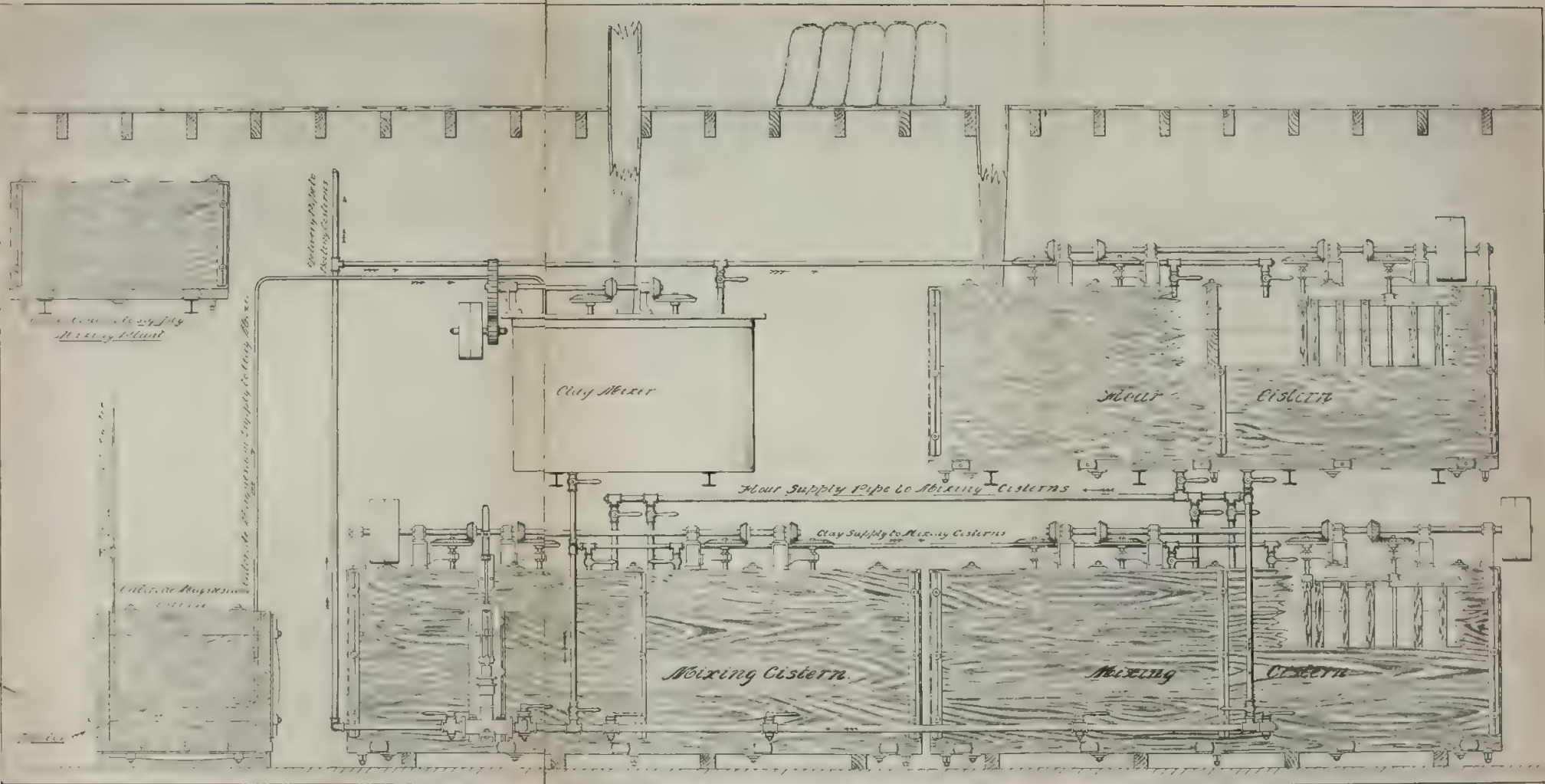
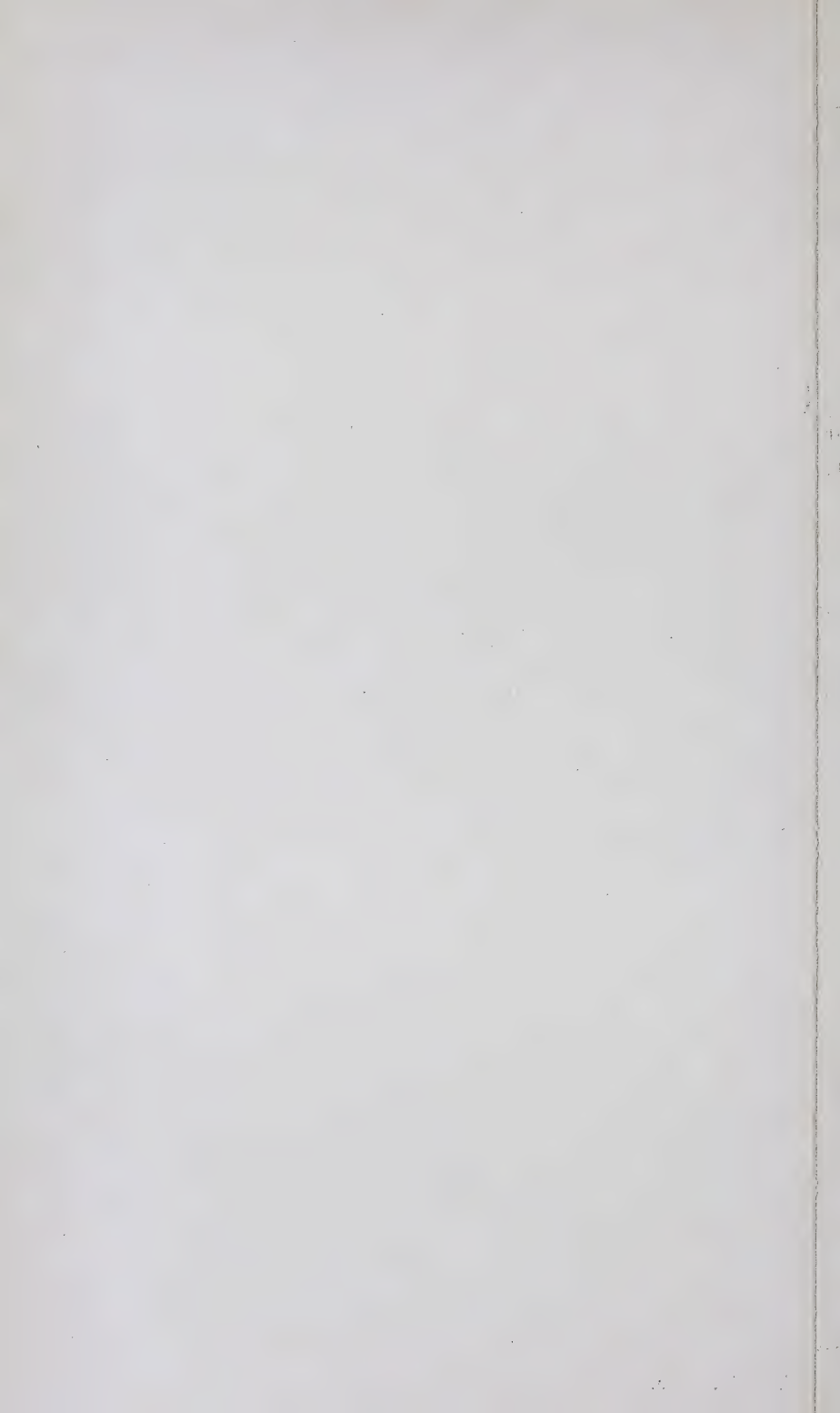


Plate XI.—AN ARRANGEMENT OF SIZE CISTERNS AND SIZE MIXING MACHINERY, by T. PARKINSON, Britannia Works, Blackburn.



be so arranged that the size-mixer has practically no lifting or carrying to do when putting down flour to steep, or mixing China clay, or making a "mixing."

In a well-equipped mill, where it is intended to manufacture "medium" or "heavy" sized shirtings, the size-rooms and machinery should be arranged as follows:—

The size-rooms should be contained in a two-storied building; the upper room being used as the store-room. This room should contain a hoist, which is used for the purpose of raising all the ingredients (except the chloride of magnesium), to the upper floor.

The flour becks, clay pan, mixing becks, and the beck for the chloride of magnesium, should be arranged on the ground floor. A number of "shoots" should be arranged leading from the floor of the store-room to the flour becks and clay pan. These shoots are used to convey the ingredients from the upper storey to the beck or pan in which it is intended to mix them.

If the size-mixing rooms are arranged in the above manner, very little manual labour will be entailed in emptying the various ingredients. A model arrangement of a size-mixing room is shown on *plate xi*.

The pipes, leading from the becks to the pump, ought to be at least two inches in diameter, in order to avoid trouble when pumping the size. The pump

should not be less than three inches in diameter, and it should have a long lift, with a fewer number of strokes, in preference to a short lift, with a higher speed. The pump ought to be coupled up to every beck and pan in the size room (the chloride of magnesium beck excepted) on both the intake and delivery sides, so that size can be pumped from any one beck to any other. All changes of direction in the piping should be made with bends of a long sweep, in order to avoid placing unnecessary work on the pump, which is the case when short elbows and sharp bends are employed.

Where the size has to be pumped long distances it is advisable to have the pump driven by a separate strap instead of by the one which drives the mixing beck.

When it is intended to go in for a variety of sizing it is advisable to have the mechanism of the becks and pans sufficiently strong to deal with the heaviest kind of size, as the power required to turn the contents of becks filled with "heavy" size is very considerable.

FLOUR BECKS.—These becks should be arranged on a higher level than those used for mixing the size, so that the flour in steep may be run from one beck to the other by force of gravity.

MIXING BECKS.—The number of mixing becks required in the size-room depends, as previously stated, upon the variety of sized goods manufactured.

Where "pure" sized goods only are made, and where flour is not used, one beck only may suffice. This beck should be divided into two or more compartments. It will then serve both for the mixing beck and for the taper's beck. The compartments of the beck are often fitted with one agitator only. This is not as suitable an arrangement for producing uniform "mixings" as a beck fitted with two or more agitators in each compartment. If more than one agitator be fitted in a compartment they should be arranged so as to just clear when at right angles to each other. Size can be mixed more uniformly, and the ingredients worked into finer particles in far less time when two agitators are fitted as shown in *plate xi*, than when the two agitators have room to clear when they are in a straight line.

CHLORIDE OF MAGNESIUM BECK.—This beck should be arranged so that the top of the beck is either on or below the floor level in the lower room. Arranged in this manner a great deal of time and work is saved, and the chloride of magnesium is more easily handled when this substance is being dissolved out by steam. The beck should be lined with sheet lead, in order to prevent the chloride of magnesium percolating through to the wood.

The chloride of magnesium beck should be provided with an ejecter leading to the clay pan.

CLAY PAN.—The clay pan should be provided with an iron cover, fitted with a hinged lid, in order

that the contents of the pan may be examined when required. When the clay is being boiled the lid should be closed.

A good sized pipe, or preferably an upright trunk, passing through the roof of the building, should be fixed to carry the steam away. If this trunk be of sufficient size to carry the steam away quickly, it enables the size-mixer to keep a fair amount of "boil" on without any fear of the clay spirting, or of the contents of the pan boiling over. The steam used in boiling also helps to break up the clay, on account of the additional agitation imparted to the contents of the pan.

Clay pans are constructed in such a way that the lower arm of the agitator is from one to three inches from the bottom of the pan. This space gets filled up more or less with clay, according to the kind of "mixing" being made. Where a variety of "mixings" are used, and the pan is a large one, it is advisable to make some allowance for the amount of clay likely to be left in this space. To illustrate more clearly what is meant by this statement, let it be supposed that the clay pan is absolutely clean, and it is intended to be used for a very heavy "mixing," containing 10 bags of clay. After the clay has been boiled, and the contents of the pan emptied as far as possible, it will be found, on examination, to contain a considerable amount of clay, especially on the bottom of the pan. As a matter of fact, half a bag

to a bag of clay might be easily left in the pan, so that if no allowance be made for this, the "mixing" might contain 9 to $9\frac{1}{2}$ bags of clay only, instead of the 10 intended.

After making a "mixing" of this description, let us assume that the pan is next used for a lighter "mixing" containing two bags of clay. As this mixing would have a larger proportion of water to the two bags, than the previous one had to the ten, the result would be that a large portion of the clay which had been left in the pan from the previous "mixing" would get worked loose from the pan bottom, and become incorporated in the second "mixing." This might then contain $2\frac{1}{2}$ to $2\frac{3}{4}$ bags of clay, instead of the two intended. This irregularity in the proportion of clay is one of the chief sources of irregular "mixings," and it is one that causes great variations in the strength of the "mixings," and in the proportion of ingredients present. It also accounts for the variations in the "feel" and the appearance of cloth which is supposed to be sized with similar "mixings."

PREPARATION OF THE VARIOUS SIZING INGREDIENTS PREVIOUS TO "MIXING."

The sizing ingredients, and the various proportions used in a "mixing," are generally kept as secret as ordinary care will allow, and there are not a few

manufacturers who assert that the "mixing" used by them contains some mysterious ingredient which makes their "mixing" superior to any other. The authors do not intend to divulge any of these wonderful secrets for the simple reason that they believe that the men who make such statements do so either in a spirit of braggadocio, or because they are ignorant of the properties of the special ingredient they are using. There is no doubt that there are certain firms who do obtain far better results in sizing than others, but this is due more to the care exercised in the selection of sizing ingredients of good quality, and to systematic methods of mixing them together in suitable proportions, than to any special ingredient they put in.

The substances generally used in sizing have already been dealt with under various headings in another portion of the book. These ingredients are all that the manufacturer need employ for any "mixing," if care be taken to obtain them of good quality.

In addition to the ingredients mentioned in the text, there are many others used in sizing. Most of them are patent (?) softeners, glycerin substitutes, tallow substitutes, patent emulsifiers, secret chemical mixings, etc. It is always claimed that they will produce a better size, bring about a reduction of the tallow usually required, save the healds and reeds, increase the average, prevent the clay dusting off,

and make a cloth which will command a higher price than can be obtained by the use of the ordinary ingredients. There is one thing, however, that the dealers in these wonderful preparations never mention: and that is, that these nostrums are produced more with the object of making large profits than with the object of materially benefiting the user. The majority of these preparations are made from similar ingredients to those in general use in the mill, and the chief addition to them is water.

The authors have no hesitation in saying that better results can be obtained at a far less cost by using the simple ingredients, mixed in a systematic manner, than can be obtained by using any of the mysterious concoctions offered to sizers.

If those who use these compounds, which only the law of libel prevents the authors from naming, only knew the component parts of many of the mixtures they purchase to put in the size, and the percentage of water contained in them, they would open their eyes very considerably.

The subject of excessive moisture in cotton is exercising the minds of many people at the present time, yet the amount of excess moisture in cotton is a mere "nothing" compared with the amount of excess moisture in many substances sold as ingredients for size. As a matter of fact, many of the patent(?) softeners contain from 40 to 97 per

cent. of water. This water is always, without a single exception, driven off when the yarns are dried on the cylinders of the tape-frame. The lost portion of the ingredient is never again recovered, so far as the cloth is concerned. When it is considered that from £10 to £20 per ton is paid for this water it will be evident that this is not an economical way of buying sizing ingredients. If, instead of using such preparations, the manufacturer would exercise a little judicious care in getting out the quantities of the various ingredients necessary for any size "mixing," he would get far better results than by trusting to some kind of patent (?) softener for which the seller could not find a market were it not for the ignorance of the buyer. Not only would his results be better, but they would be attained in a much more economical way. The authors have no hesitation in stating that many firms could save from £300 to £500 per annum in their sizing bills if they would only place their sizing arrangements on a scientific (common-sense) basis. As a matter of fact the writer has reorganised the sizing in certain mills where as much as £2,000 per annum has been saved, and better results have been obtained in the weaving.

Before going into details in regard to size "mixings" it will perhaps be advisable to discuss the ingredients separately, and give the method of treating each before it is mixed with the others.

This matter has already been briefly dealt with in the previous chapters, and the authors will now go more fully into details.

TREATMENT OF FLOUR.—It has already been stated that there are two methods of treating flour for sizing purposes, viz.:—By fermentation, and by “steeping” with chloride of zinc. In the process of “steeping” there is far less trouble, and for ordinary sizing the authors are firmly convinced that more uniform results are obtained than can be obtained by the process of fermentation.

The “steeping” process is to be preferred to the fermentation process for several reasons. In the first place it prevents, in the most effective manner, the development of mildew growths. In the second place, there is no possibility of loss on account of the contents of the beck overflowing, as sometimes occurs during fermentation. And in the third place it prevents putrifaction setting up.

The proportion of water required for every 280 lbs. of flour is from 25 to 30 gallons. The water should first be carefully measured into the flour beck, and the chloride of zinc ($3\frac{1}{2}$ to 4 gallons at 102° Twaddell to a pack of 280 lbs.), added. The flour is then placed in the mixture of water and chloride of zinc, and agitated till ready for use. It is then pumped into another beck, which is used for the storage of flour which has previously been got ready for use. In preparing a “mixing,” the flour

should be taken from the second beck, care being taken that the contents are well agitated previous to running any out.

Care must be taken not to use too large a proportion of water per pack of flour, otherwise the mixed flour will be too thin. The effect of this condition would be, that, if the agitators were allowed to stop for a lengthy period, the starch in the flour would settle to the bottom of the beck in a hard mass. The authors know of cases where it has been necessary to run off the top water, and then dig the greater portion of the hard mass of starch away from the agitators with a spade before the latter could be moved.

MEASURING THE MIXED FLOUR.—Opinions amongst sizers differ considerably as to the best way of dealing with the flour in steep when making a mixing. It is a very common practice to calculate the proportion of the mixture of flour and water to be used in a “mixing” by taking the specific gravity or Twaddell of the mixture. This is an unscientific and unsatisfactory way in every respect and it leads to variation in the results.

Twaddells, or hydrometers, are intended to indicate the specific gravity of *liquids*, but a mixture of water, chloride of zinc, and flour, is not a liquid in the true sense, and the strength, as indicated by the Twaddell, may be misleading owing to the fact that the flour will gradually Twaddell a less number

of degrees as it gets more broken up. The time required to thoroughly break up the flour depends upon several factors, viz.:—The nature of the flour, the amount of water which is added to it, and the amount of agitation which is employed. It will be readily seen therefore, that taking the strength of the flour mixture by “Twaddelling” is most misleading and unsatisfactory.

If, instead of trying to bring the mixture of flour and water to any particular Twaddell, the mixture was made in such a way that a given volume of it represented a definite weight of the original solid flour, the “mixings” would be much more uniform.

The correct method to adopt is to find out exactly what depth of water in inches should be run into the beck per pack of flour (280 pounds). This can easily be ascertained, either by pouring the required number of gallons of water per pack of flour into the beck, and making careful measurements of the increased depth by means of a rod, or by calculation from the capacity of the beck. Thus, length \times breadth \times depth will give capacity in, say, cubic inches; and 1,728 cubic inches = $6\frac{1}{4}$ gallons. The increase in depth is then multiplied by the number of packs of flour it is intended to put down. When the amount of water required is known, the full quantity may be easily and accurately measured as follows:—The agitators are first stopped and the

movement of the flour allowed to cease. A long rod is then placed to the bottom of the beck, care being taken to hold it perpendicularly. The portion which has been immersed will be covered with flour and water. A distance should be then measured from the top of the immersed portion equal to the amount it is intended to add to the height of the contents of the beck. At this point a nail is knocked into the rod at right angles to it. The end of the rod is then put to the bottom of the beck, and water is run in until the height indicated by the nail is reached.

If this operation be carefully carried out every time the flour is put down there will always be a measured amount of water to a known weight of flour, and every gallon of the mixture will represent a known weight of the original flour. More uniform results will be obtained in this way than by placing an unknown quantity of water in the beck to begin with, and afterwards trying to get a uniform strength by adding more water until the mixture of flour and water Twaddells a certain number of degrees.

When a large number of packs of flour are being put to steep in the beck it is advisable to allow more time to elapse before adding each succeeding pack, than where a few packs only are being put down. If this be done it causes the flour to become properly mixed much sooner than if there were no interval. It also avoids excessive strain

on the agitators and driving strap. Thus, if it be intended to put down eight or ten packs of flour, it would be far better if four or five packs were mixed on the first day, two more on the second day, and one more on each succeeding day, than if the whole of the flour were mixed at once.

For the first few days after being put down it is evident, from the appearance of the contents of the beck, that the ingredients are not thoroughly mixed. Each succeeding day however, the mixture looks thinner, and probably in a week or ten days it will have a limpid appearance, and it will splash about the beck when the agitators are rotating. Previous to the mixture having this appearance it is not advisable to move the flour from the first beck, and nothing will be lost by keeping at least a few weeks' supply in the second beck.

TREATMENT OF THE VARIOUS STARCHES.—The pure starches, such as farina, sago, maize and rice, require no special treatment. There is no necessity to steep or ferment, and all necessary details have been given in the first chapter of the book.

TREATMENT OF CHINA CLAY.—The method of treating China clay has already been described. The question of boiling China clay, and the advantages of using powdered China clay, have been fully dealt with on pages 151 to 154. Until powdered clay can be obtained as easily as the

present form, the question of boiling must be considered.

The time required for boiling clay depends largely upon the work for which it is intended. As the only object of boiling is to separate the particles of clay, the time occupied by this process depends upon whether the "mixing" be a "light" or a "heavy" one.

For "light" sizing, where a large quantity of water can be used to a small amount of clay, it is not necessary to boil for more than an hour. In heavy "sizing," where the quantities are reversed, the clay should be boiled for at least three or four hours, otherwise the particles do not get separated sufficiently to produce good work.

CHLORIDE OF MAGNESIUM.—This substance is bought, as a rule, in the solid state. To make a solution, a hole is bored in the cask, and a small pipe inserted, through which steam is passed, and, as it condenses, the chloride of magnesium is dissolved. The solution is allowed to run into the beck provided for its reception. This beck is generally lined with lead, to prevent the contents percolating through the wood. The solution of chloride of magnesium should be brought to a definite strength as indicated by the Twaddell. This varies according to individual ideas, and may range from 50° to 66° Twaddell. There is no one particular strength which is more conducive

to good work than another, but it is absolutely essential that the Twaddell should be the same for every "mixing," otherwise the results will not be uniform, even though the same volume has been used. It is not advisable to prepare chloride of magnesium solution at a higher Twaddell than 66°T, as above this strength it has a tendency to crystallize out on the bottom and sides of the beck. To keep the strength constant, the liquid should be Twaddelled before being used, care being taken that the contents of the beck have been well agitated before placing the hydrometer into the liquid. The Twaddell should always be taken at a given temperature. If the Twaddell be too high, water should be added carefully until it is of the required specific gravity.

The usual method of measuring the solution of chloride of magnesium, when making a "mixing," is generally a very crude one. A bucket is usually used for this purpose. If the *exact* capacity of the bucket be known, and the same size of a bucket be used every time, this method may be all right, but the authors prefer to have an ejector fixed at the bottom of the beck, and to measure the quantity of solution required in inches, by means of a rod and nail as used for measuring flour. The number of gallons per inch of depth may be easily ascertained, and from this data the quantities may be calculated in terms of inches. By this method it is impossible

for the size-mixer to forget how many bucketfuls he has put in the "mixing" when part way through his work. It also economises labour, and at the same time keeps the size-room cleaner. There is no possibility of spilling the chemical on the floor, as is the case when it has to be carried from one beck to another.

The authors would here again emphasise the importance of making measurements with the greatest care.

CHLORIDE OF ZINC.—The method of mixing chloride of zinc has already been given on pages 81 and 254. The size-mixer should record in a book the number of the cask and the date on which it was received. He should also record in this book the strength, as indicated by the Twaddell, of the first bucketful drawn from every cask. This is a most important check, and it becomes a valuable record if damage should occur to the cloth at a later stage.

METHOD OF MIXING THE SIZING INGREDIENTS.

"Mixings" are generally made to put a known percentage of size on known counts of yarn. The right proportions of the various ingredients for a certain percentage of size depends, to some extent, upon the kind of cloth it is intended to make. A good weaving "mixing" to put 40 per cent. of size on a "thin sort," say a 12 × 10, would not be

suitable to put the same per cent. of size on the same counts of yarn for a 20 × 20. If the "mixing" be suitable for the "thin sort," there is every probability that it would be too soft for the "strong sort," and *vice versa*.

The proportions of the ingredients used in a "mixing" vary also in different mills for many other reasons. In the first place, the quality of the ingredients affects the results. In the second place, the proportions may vary on account of the different treatment they receive in preparing a "mixing." For instance, a "mixing" not previously thoroughly boiled before being used by the taper, would require less starchy matter than one boiled for a few hours. Again, if the same quantity of starchy matter be used, the "mixing" which has not been boiled will produce a harder feeling cloth, and one more free from "dustiness," than a "mixing" which had been boiled through. In the third place the "feel" required for a particular cloth has to be taken into consideration. Thus a soft smooth "feel" would require a slightly different "mixing" from that required for a rough "grippy feel," even when the percentage of size is the same in each case.

The authors have already pointed out that it is almost impossible to get uniform results in sizing where it is the practice to ascertain the strength of a mixture of flour and water by means of the Twaddell's hydrometer. This objection to the use of

the Twaddell for such a purpose applies even more to the practice of trying to ascertain the strength of a completed "mixing." The strength of the "mixings" for a certain percentage of size, as indicated by the Twaddell, may vary considerably in different mills owing to the difference in the quality of the ingredients used. China clay affects the accuracy of the Twaddell test more than any other ingredient, on account of the variation in the physical characters of different clays. The Twaddell should be confined to testing the chlorides of magnesium and zinc, and the strength, or consistency of the "mixing," should be kept uniform by weighing all the solids and measuring all the liquids. The same weights should be put down every time, and the liquids (including the water) should be carefully measured. If this be done better results will be obtained than if the "mixing" be made too strong in the first place, and water afterwards added to reduce it to the right strength, as indicated by the Twaddell's hydrometer.

From what has been said, it will be obvious that it is almost impossible to have a mixing which would be suitable for all mills, unless the ingredients, and the treatment accorded to them, were exactly the same. Even if this were done it is probable that the geographical position of the mill might entail slight but necessary alterations. A mill situated on the top of a hill would require a slightly different mixing for "heavy" size from that required for

the same purpose in one placed in a valley, and well shielded from the weather. *All "mixings" given in books, therefore, should be used as a basis only.* They may, and probably will, especially for "heavy" sized goods, require alterations to suit the particular conditions under which the cloth has to be woven. The only sure rule known to the authors for making these slight, but important alterations correctly, is "*the rule of experience.*" This experience can be obtained by making alterations in the proportions of the ingredients of a "mixing," and carefully observing the effects produced in the weaving, and in the "feel" of the cloth. If there be added to these experiments a sound general knowledge of the properties of the ingredients used, there should be no difficulty in making a suitable mixing for any class of sizing.

MIXING "PURE" SIZE.—Mixing "pure" or "light" size is a very simple matter compared with mixing "medium" or "heavy" size. The required quantity of water should be placed in the pan or beck in which it is intended to make the "mixing." The starch and tallow are afterwards added and the mixture is heated sufficiently to burst some of the starch granules. This causes the "mixing" to thicken slightly, and in this condition the tallow or wax is more easily incorporated. The starch is also prevented, by this partial gelatinization, from settling to the bottom of the beck.

Another method which is sometimes adopted, is to boil the "mixing" until it becomes thin enough to pass through the pump. This method undoubtedly gives a softer "feel" to the cloth, and more pliability to the yarn, but it is not advisable to treat all "pure" size mixings in this manner. For instance, this treatment would be objectionable for a mixing consisting principally of farina. It has been frequently stated that farina loses its adhesiveness to a greater extent than any other starch by prolonged boiling, and such treatment would have disastrous results in the weaving shed when the yarn came to be woven. There are other objections to boiling a "mixing" in bulk before it is pumped to the taper. These will be discussed under "medium" and "heavy" size.

MIXING "MEDIUM" AND "HEAVY" SIZE.—The method to be adopted in mixing "medium" and "heavy" size differs somewhat from that employed for "light" size. In the first place there are more ingredients to consider, and in the second place they require different treatment. The following procedure may be usually adopted:—The necessary amount of water should first be put into the mixing beck or pan. Afterwards the China clay should be added and the chloride of magnesium. (In the case of "heavy" size it is necessary to boil the chloride of magnesium with the clay because the proportion of water available to boil the clay is small). In

“medium mixings” it is not necessary to add the chloride of magnesium until the clay has been boiled. These ingredients are then boiled for a period varying from one to four hours, according to the class of mixing; longer boiling being required for the “heavier mixings” than for the “lighter mixings” in order to bring about the separation of the particles of clay.

After the mixture of water and clay, etc., has been boiled the necessary length of time the tallow should be added, and the whole boiled for a few minutes. In the meantime, the flour should be run from the flour beck into the mixing beck, the latter beck being arranged immediately under the clay pan. When the China clay has cooled sufficiently to allow its admixture with the flour it is run into the mixing beck and thoroughly mixed with the flour. This completes the “mixing.”

If it be necessary to add blue to the “mixing,” or to otherwise alter the colour of the size, the requisite amount of colouring matter should be introduced at this stage, and the “mixing” agitated until it is required by the “taper.”

The amount of time elapsing between the making of a “mixing” intended for “medium” and “heavy” sized goods, and its use in the tape-frame, may make a difference in the weaving, and in the general appearance of the cloth. Where there are a sufficient number of becks to allow a few days, or

s

even a week, to elapse between the making of a "mixing" and its use, the ingredients get *worked up finer*, and the whole mass is more *uniform*. This tends to produce a better looking and more uniform cloth, and one with a smoother "feel" than would be the case if the "mixing" were used immediately after being made.

It has been mentioned under the mixing of "pure" size that it is customary in some mills to boil the size in the mixing beck before *going to the taper*. It is not always convenient to boil "medium" or "heavy" size sufficiently thin to enable it to be pumped to the sow-box because the size-mixing plant is not always adapted for it. But where the plant is suitable, and the boiling is done in the right way, there is no question that better results are obtained in every way. In the first place the yarn is rendered more pliable, thus producing better weaving. In the second place the cloth has a much better appearance when woven than it would have if the size were simply boiled in a small enclosed pan attached to the tape-frame previous to being boiled in the "sow" box.

Some of the chief advantages to be gained by thoroughly boiling a "mixing" and completely gelatinising the starch granules are as follows:—In the first place the starch is divided into minute particles, in which state it can be intimately mixed with the other ingredients of the size. In the second place,

starch which has been completely gelatinised prevents to a great extent the China clay from settling out and sinking to the bottom of the beck. It also assists in keeping the tallow or wax in suspension, and there is not the same tendency for these substances to separate out and float on the surface when the "mixing" cools. Conditions such as the above all make for uniformity in the results obtained in sizing.

It may be as well to point out at this stage that some of the starches, such as sago, rice, and maize, require not only a simple boiling, but the operation must be prolonged sufficiently to *cook* them, otherwise the best results cannot be obtained. On this account it is necessary to continue the boiling of these starches for three or four hours before using them.

When conducting the boiling operations for a large "mixing" it is never advisable to attempt to boil the whole mass at once. If this were attempted the granules of the starchy matter would be too rapidly gelatinised, and the probability would be that the agitators in the beck would be stopped on account of the "mixing" becoming converted into a solid mass. The proper method to adopt in boiling is the following:—A portion of the "mixing," say about a foot in depth, should be pumped into the pan or beck in which it is intended to be boiled. This should be first boiled until it is thin enough

to allow the agitators to revolve at their normal speed. The remainder of the mixing should then be pumped into it. If a good supply of steam has been arranged to the boil pipe the size will be boiled as fast as it is pumped into the beck.

Although it is advisable to boil all "mixings" through before *going to the taper*, this is sometimes inconvenient, owing to the variety of sized goods manufactured. In a mill where only two or three sorts of size are used, and these are of a "light" or "medium" nature, it is possible to carry out this operation, but where a large variety of sized goods are produced, each having their distinctive weights and "feels," it is much more convenient to have a good form of boiling pan attached to the tape-frame. This point will be further discussed in the chapter on "taping."

A constant source of trouble to be guarded against is the tendency of boiled size to block up the pipes, or settle in a hard mass, if allowed to remain motionless for a few hours. This may be prevented, in the first place, by means of a pump sufficiently large to keep a good flow of size through the pipes during working hours. A 3-inch pump with a 7-inch lift would be suitable for this purpose. In order to prevent the size settling in the pipes when the pump is not working, as during meal hours, and at night, steam should be forced through them. For this purpose a $\frac{1}{2}$ -inch steam pipe should be coupled to

the "size" pipe, between the beck tap and the pump. The pipes can thus be emptied of their contents by stopping the pump, and turning on the steam. This will first force the size back into the beck. The beck tap should then be shut, when the size will be forced along the pipes to the "tape-frame," and the overflow, and thus the pipes will be entirely emptied.

SIZE "MIXINGS" FOR VARIOUS WEIGHTS.

As previously stated, it is not possible to lay down "mixings" for any given weight of size which will be suitable for all conditions. The "mixings" here given are practical working recipes, but they should be used as a basis only.

In every case where flour is mentioned it is assumed that this ingredient has been mixed and steeped with chloride of zinc in the proportion of $3\frac{1}{2}$ to 4 gallons for each 280 pounds of flour used.

In "pure" sizing the strength of the size will depend upon the fineness of the reed, the number of picks it is intended to put in the cloth, and the counts of yarn, both twist and weft. The strength will vary also according to the kind of cloth it is intended to weave. Thus, a heavily picked plain cloth will require a greater percentage of size on the yarn than a twill or a sateen with the same number of picks, owing to the difference in the interlacing of the warp and weft threads.

In making alterations in the strength of a "pure mixing" it may be taken as a general rule, that, with a given weight of starchy matter, the proportion of softener (tallow, wax, or soap) will have to be increased if a less quantity of water be used in order to make a stronger "mixing." To illustrate this more fully, suppose "mixing" No. 2 was giving satisfactory results for a 16×14 cloth with 160 gallons of water, and 12 pounds of tallow, and the taper required a set of beams for a 22×20 "sort." If the "mixing" were not altered the stronger "sort" would be too soft. To avoid this a "mixing" would have to be made with the same weight of starch, but with 130 gallons of water, and 20 or 25 pounds of tallow.

The method of mixing the size will cause variations in the quantity of water required. If the "mixing" be simply heated until a portion of the starch granules burst more water may be used to a given weight of starchy matter than if the "mixing" be boiled for three or four hours, previous to its being used by the taper. In the latter case an allowance must be made for the extra water caused by condensation during the period of boiling. Not only must an allowance be made for the quantity of water, but the amount of tallow or other softener can be reduced in "mixings" which have been subjected to a prolonged boiling.

The quantity of water given in the "mixings" on

page 296, *et seq.*, allows for rather more than the average amount of condensation of steam in the size-mixing beck and in the "sow" box.

It is impossible to give the *exact* quantity of water for a "mixing," owing to the number of practical details which may cause it to vary in different mills. This can be ascertained only by practical experience. For instance, to put on a given percentage of size the quantity of water required for a "mixing" where soft spun mule yarn is being used would have to be decreased if a change were made to ring spun yarn. Again, more water could be put to a "mixing" in a mill where the size-mixing apparatus and the slashing machine were in close proximity to the boiler than where the sizing operations are a considerable distance away from the steam supply. In the latter case there would be a very large amount of condensation on account of the greater distance the steam has to travel before being used. When the steam has to travel through a long range of piping it is advisable to have the pipes covered with some substance which is a non-conductor of heat. In this way a large amount of condensation is prevented. It is also advisable to insert some form of steam trap or separator as near to the tape frame as convenient. This will eliminate a large proportion of the condensed steam, and thus prevent the size being weakened

Another factor which may cause a variation in the amount of water required for a "mixing" is the weight of the finishing roller. If a change were made in this roller, and the weight were increased from 360 to 480 pounds, it would be necessary to reduce the quantity of water used in the "mixing." This is because a heavy roller will squeeze more of the size from the yarn than a light one, and to compensate for this the size must be made stronger. It may be as well to state here that a heavy finishing roller, with the "size" of the right strength, will give a better appearance to the woven cloth than can be obtained with a light roller.

The following "mixings" are based upon the use of a standard flour and a standard China clay, and any deviation from these ingredients must be allowed for :—

NO. 1—"PURE" SIZE.

Water.....	120 to 180 gallons.
Tallow or Wax	10 to 30 pounds
Farina	224 pounds.
Chloride of Zinc, 102°T	2 gallons.
Caustic Soda, 70°T	2 pints.

NO. 2—"PURE" SIZE.

Water.....	110 to 160 gallons.
Tallow	10 to 30 pounds.
Farina.....	112 pounds.
Sago	112 pounds.
Caustic Soda, 70°T	2 pints.

The use of chloride of zinc to "pure mixings" is optional: but when it is omitted, the yarn should be more highly dried in the taping.

The addition of glycerin to the "pure" size "mixings" will improve the weaving, but if the goods are intended for shipment in the grey state, it will be desirable to add either chloride of zinc or salicylic acid, in order to prevent mildew developing during transit to the East. If salicylic acid be employed as the antiseptic, it should be used in the manner described on page 257, and in the proportion of 6 ounces to every 100 pounds of starch.

No. 3—MIXING FOR 30 TO 40 PER CENT.

Water.....	90 gallons.
Chloride of Magnesium, 60°T...	6 gallons.
China Clay	224 pounds.
(West of England Stone and China Clay Co.'s Special Super), see page 149.	

Tallow	30 pounds.
Flour	280 pounds.
(H. Hibbert & Co.'s 3H.), see page 86.	

The flour is assumed to have been previously steeped with the necessary proportion of chloride of zinc.

No. 4—MIXING FOR 45 TO 60 PER CENT.

Water.....	140 gallons.
Chloride of Magnesium 60°T...	15 gallons.
China Clay	672 pounds.
(West of England Stone and China Clay Co.'s Special Super) see page 149.	

Tallow	90 pounds.
Flour	448 pounds.
(H. Hibbert & Co.'s 3H.), see page 86.	

Maize Starch (Corn Starch)	112 pounds.
Chloride of Zinc, 102°T	2 gallons.

The chloride of zinc here mentioned is put in to counteract the tendency of the starch to mildew; the flour having been steeped with chloride of zinc, as mentioned in No. 3.

No. 5—MIXING FOR 80 TO 100 PER CENT.

Water.....	80 gallons.
Chloride of Magnesium, 60°T...	20 gallons.
China Clay	896 pounds.
(West of England Stone and China Clay Co.'s Special Super), see page 149.	
Tallow	120 pounds.
Flour	320 pounds.
(H. Hibbert & Co.'s 3H.), see page 86.	
Farina or Maize Starch	40 pounds.
Chloride of Zinc, 102°T.....	$\frac{1}{2}$ gallons.

The chloride of zinc here mentioned is put in to counteract the tendency of the starch to mildew; the flour having been steeped with chloride of zinc, as mentioned in No. 3.

No. 6—MIXING FOR 140 TO 160 PER CENT.

Water.....	75 gallons.
Chloride of Magnesium, 60°T...	35 gallons.
China Clay	1792 pounds.
(West of England Stone and China Clay Co.'s Special Super), see page 149.	
Tallow	230 pounds.
Flour	340 pounds.
(H. Hibbert & Co.'s 3H.), see page 86.	
Maize Starch.....	120 pounds.
Chloride or Zinc	$1\frac{1}{2}$ gallons.

The chloride of zinc here mentioned is put in to counteract the tendency of the starch to mildew; the flour having been steeped with chloride of zinc, as mentioned in No. 3.

As previously stated the above mixings should be used as a basis only. Modifications may have to be made according to conditions under which the cloth is woven and also according to the feel

required in the woven cloth. Many other mixings for special results could be given, but unless the exact requirements of the sizer were known they might lead to confusion and mistakes. For instance, at the present time there is a great demand for cloth for native dyeing. This cloth has to be fairly heavily sized and it must take dye well. The dyeing operations are conducted by natives principally in India, China and Egypt.

For a long time no one seemed to know exactly what form this native dyeing took. It used to be reported to the writer that the cloth was dipped "in a native dye," and that some cloths took the dye better than others. In the course of time, the writer found that the dyeing was practically confined to indigo, and that those cloths which had a good reputation for taking the dye well contained the least amount of tallow.

When the demand for this special cloth first became general, manufacturers seemed to have an idea that it was simply a case of dipping the cloth into a mixture of indigo blue and water, and that the pigment was fixed or plastered on in some mysterious way. As a matter of fact the natives of India, China and Egypt, have some considerable knowledge of the use of dye stuffs, an art which has been handed down from past generations, and their dyeing process is more or less like the processes adopted in this country, *i.e.*, the indigo is reduced

and brought into solution and afterwards precipitated in the fibre.

It is impossible to get ideal conditions for dyeing heavily sized cloth, as the size resists the dye. The principal ingredient which affects the dyeing of such cloth is the tallow or other fatty substance which has been used as a "softener." Grease resists liquids and prevents the dye liquor penetrating the fibre. The only method of overcoming the difficulty is to use the minimum quantity of tallow or other fatty "softener." At the same time it must be understood that this will affect the weaving. Tallow is not put into a mixing for the sake of putting it in, and generally sizers will err on the side of economy without much pressure.

The writer has laid down scores of mixings in recent years to meet the requirements of the merchants, and in some cases mixings have been employed which did not contain any fatty matter whatever. In all cases of this kind the writer has warned the manufacturer that he was bound to have trouble in some form or other with the weaving. Not only is the weaving not good, but there is a danger of iron staining in the looms. Although there are many difficulties to contend with in this class of goods, it is possible to size the yarn in such a way as to obtain the best possible results with the minimum of risk. At the same time it would be unwise to publish mixings broadcast for sizers to

use under conditions unknown to the writer because loss and damage would probably occur, and this loss would be attributed to the mixing. Cases of this kind require dealing with personally, and the writer would urge upon all sizers not to experiment in this matter without expert advice, as the possible loss due to trying to avoid the expense of advice may be many times greater than any possible fee. Not only is there a danger of loss from spoiled material, but there is also the far greater danger of loss in reputation with the merchants at home and abroad.

SIZE MIXINGS WHICH CAUSE TENDERING
WHEN THE CLOTH IS SINGED.

Whilst discussing the question of size mixings the authors would like to call attention to the demand which is being made at the present time upon manufacturers of cloth intended for bleaching. Merchants are requesting that the yarns shall be fairly heavily sized, on the ground that the cloth “finishes” better. This is an absurd contention, and it is leading to many claims for damages. *In the first place the authors state distinctly that a large proportion of size does not improve the “finish” of the cloth after it has been bleached, and in the second place a large proportion of size cannot be put on the yarn without the use of chloride of magnesium, chloride of calcium, or chloride of zinc.*

Manufacturers who have met the requirements of the buyers have had claims made against them for damage caused by tendering which has developed when the cloth is singed previous to bleaching, or they have had claims put in for washing the cloth before it has been singed because the bleacher has found chloride of magnesium, etc., present.

It should be understood once for all that ordinary counts of yarn cannot be sized successfully more than 20 per cent. without the use of deliquescents, and manufacturers will be well advised if they refuse to accept the conditions imposed. If a merchant wants more than 20 per cent. of size on the yarn for ordinary counts he should be made to accept full responsibility for all damages from its presence.

With regard to the contention that the cloth "finishes" better an explanation of how this mistaken idea has crept in may help to stop the trouble in future. Supposing that two pieces of cloth are sent to be bleached and finished, and they are identical in reed and pick, and in counts of twist and weft. One piece is sized sufficiently for weaving only whilst the other contains 20 per cent. of size on the twist. The heavier sized piece will be fuller and heavier than the pure sized cloth for a given length, and it will *appear* to be of greater value. When these two cloths are bleached and "finished" they will probably be returned to the merchant *about loom weight*, and the cloth which was more

heavily sized originally will be fuller, and have a better "finished" appearance than the lighter sized piece. If, however, the latter cloth had as much "filling" put into it by the "finisher" as the former it would have the same feel and appearance. The "finisher" can get the desired effect by suitably "filling" without the manufacturer being requested to waste material which has to be entirely removed before the cloth can be properly bleached. In the process of bleaching not only is the added size removed, but a considerable proportion of the natural constituents of the cotton as well, otherwise the bleaching could not be properly carried out. Merchants are asking for impossible conditions when they require the yarn to be sized as much as 30 per cent. and upwards, and at the same time request that no substances shall be used which may damage the cloth when it is "singed." There is a limit to what can be done in this way.

There is another reason why merchants are asking for cloth to be extra weighted in the grey state.

A great deal of pure sized cloth is sent abroad to be bleached and embroidered, and if this cloth is not above a certain weight for a given length and width it is charged duty at a higher rate than if it conformed to a certain weight. This has led merchants to ask for more size, the only use of which is to save the extra duty. Many manufacturers have overcome the difficulty by dusting China clay

between the folds of the cloth as it has been lapped on the folding machine.

The only way to prevent claims for damages in cloth which has to be bleached, is for all manufacturers to firmly refuse to put more size on the yarn than is required for weaving unless the merchant will accept full responsibility for conditions altogether unsuitable for safety and good weaving.

COLOURS USED FOR TINTING THE SIZE.

It is a common practice to tint the size. This is done with two objects. In the first place the operation is carried out in order to reduce the yellowish tint natural to cotton. For this purpose blue of some description is used. In the second place the operation is carried out for the purpose of giving some distinctive tint to the cloth. In the latter case the object is generally to produce a shade on American cotton similar to that possessed by Egyptian cotton. Sometimes this is done for the purpose of deceiving the buyer, but very often it is done with the object of producing a cloth with a pleasing shade of colour. Not only is tinting being carried out for the purpose of imitating the shade of Egyptian cotton, but, at the present time, it is being largely carried out for certain fabrics, the yarns of which were formerly dyed previous to sizing. For this purposes many shades of greens,

blues, yellows, etc., have to be obtained, A list of the dyes, from which most of the tints can be obtained, is given below.

The colours generally employed in tinting are obtained from the coal tar or aniline colours. In some cases pigment colours, such as ultramarine blue, yellow ochre, brown umber, and the chromate, and oxychromate of lead, are used. Occasionally indigo blue is employed. With the exception of ultramarine and indigo, these colours are not so suitable as coal tar colours for tinting size.

COAL TAR COLOURS.

These colours may be divided into two classes, viz. :—basic colours and substantive colours, the latter being known as “direct” colours. The following is a list of the principal coal tar colours used for tinting size :—

BASIC COLOURS.	SUBSTANTIVE OR “DIRECT COTTON COLOURS.”
Methylene Blue. Methyl Violet. Bismarck Brown. Auramine Yellow. Chrysoidine Orange Saffranine.	Benzo Sky Blue. Diamine Sky Blue. Benzo-chrome Brown. Chloramine Yellow. Mikado Orange. Fast Benzo Red 4B. Geranine Pink. Erica Pink.

BASIC COLOURS.—These colours fade much more rapidly under the action of light than substantive colours.

The various basic colours here mentioned are employed for the following purposes:— Bismarck brown is used for the production of dark cream shades and buffs. It is used also for imitating the colour natural to Egyptian cotton, but when used alone it does not give very good results for this purpose. Mixtures of auramine yellow and chrysoidine orange yield any shade of cream which may be desired. These two colours when mixed in suitable proportions produce a shade which is a very good imitation of Egyptian cotton. Methylene blue and methyl violet are largely employed for the purpose of reducing the yellowish shade natural to cotton. Care should be taken when selecting a blue that it possesses a reddish shade. The red has the power of neutralising the natural yellow tint of the cotton and produces a white effect, whereas some blues produce a greenish shade in the cloth which is very objectionable. Methylene blue and methyl violet are also employed for the purpose of giving a blue tint to the yarn.

Basic colours may be dissolved by first mixing the dye with sufficient water to form a paste, afterwards adding a small quantity of acetic acid, and finally the necessary quantity of water. The following proportions should be used to make a standard solution:—

Basic Colour	...	...	...	4 ounces.
Acetic Acid	...	...	...	5 ounces.
Water	...	...	...	1 gallon.

Instead of acetic acid and water, methylated spirit might be used for sizing purposes.

SUBSTANTIVE COLOURS—DIRECT COTTON DYES. These colours are faster to light than the basic colours, and they are with difficulty removed by bleaching; in fact, it is impossible to discharge the colours entirely without destroying the cloth. Substantive colours should be used always in alkaline solutions. The various colours given in the list may be used for the following purposes:—benzo sky blue, and diamine sky blue, may be used for producing blue tints, or for reducing the yellowish shade of the cotton. Benzo-chrome brown may be used for dark creams and buffs. Mixtures of chloramine yellow and Mikado orange, or mixtures of chloramine yellow and benzo-chrome brown, will produce any desired shades of cream. These latter colours may be used also for imitating the shade of Egyptian cotton, a subject which will be described on page 311. Various shades of green may be obtained by mixing the blue dyes with the yellow and orange dyes.

Substantive colours should be dissolved by boiling with water and a little soda ash in a suitable vessel. The following proportions may be used in order to make a standard solution:—

Substantive Colour	...	...	...	8 ounces.
Soda Ash	...	...	...	8 ounces.
Water	...	...	...	1 gallon.

METHOD OF MIXING THE COLOURS WITH
THE SIZE.

The solution of dye should be strained through a fine cloth previous to being mixed with the size. The colour is run into the "mixing," as described on page 289.

It is important to remember that on no account should basic and substantive colours be mixed. They are diametrically opposed to each other in properties, and will, on being brought together in solution, precipitate each other. Cases are not unknown where colour dealers have sold basic colours and substantive colours to manufacturers to be used together to produce a certain shade. In some cases the right tint has been obtained with such mixtures of dyes, so long as the size "mixing" was cold, but as soon as it was boiled, a different shade altogether was produced.

ULTRAMARINE BLUE.

This pigment is a mineral colour and is produced by heating together in certain proportions China Clay, sulphate of soda, charcoal, and sulphur. The honour of having produced ultramarine falls to Grumet and Gmeling. These chemists devised methods for its manufacture independently of each other. Previously it was prepared from the precious stone *lapis lazuli*, which was ground to a fine powder and used for painting, but its price was very high.

Ultramarine is produced in two distinct stages :—

1st.—The preparation of green ultramarine.

2nd.—Conversion into blue ultramarine.

In the first operation the China clay, charcoal, and sulphate of soda, are well ground together, and then ignited in a suitable furnace. A white mass is produced, which, on exposure to the air, becomes green. The blue ultramarine is produced by roasting the green product with sulphur at a low temperature in contact with the air. The conduct of all the operations requires great care and skill.

Ultramarine is not affected by light, air, or alkalies, but acids rapidly discharge the colour, at the same time liberating the nauseous smelling gas sulphuretted hydrogen.

Ultramarine is frequently adulterated. The best method of judging the quality of a sample is to compare its colour with a standard sample. The substances used for the adulteration of ultramarine are finely-powdered glass and sulphate of barium. Both substances, but especially the sulphate of barium, reduce the tinting power of the blue.

USE OF ULTRAMARINE BLUE IN SIZING.—This blue is one of the best for reducing the yellowish shades of cotton. It does not deteriorate on ageing. The method which should be employed for mixing the colour is as follows:—A standard mixture is prepared by mixing one pound of blue with one gallon of water. The water should be

added gradually, just sufficient at first to form the colour into a thick smooth paste. The rest of the water is then stirred in. On no account should the ultramarine blue and water be boiled together. Boiling causes the solid particles of the colour to settle out. Some sizers add acid, such as hydrochloric or sulphuric acid, to the mixture of ultramarine and water, with the view, as they say, of bringing the colour into solution. It has been stated previously that acids decompose this colour, and all that goes into solution is that which has become decomposed, and which has in consequence entirely lost its colour. Such a method is very objectionable.

Ultramarine blues differ considerably in shade of colour. Those most suitable for producing a good tint have a reddish shade. This more readily disguises the faint yellow tint possessed by the cloth.

INDIGO BLUE.

This substance is one of the most important colours used in printing and dyeing, possessing as it does the most valuable of all qualities—fastness. Indigo Blue is rarely used for tinting, and only when specially requested. It should be ground into a paste with lime water in a suitable mill. This paste is further diluted with water and strained through a fine cloth before being added to the mixings.

Indigo is a derivative of plants of the family of *Papilionacæ*, of different species of indigofera, which grow in India, China, etc. One of the most valuable properties of indigo is that it can be converted, by reduction, into *indigo white*, a body which is soluble in weak alkaline liquids. If a fibrous material be immersed in a bath of reduced indigo white solution, it absorbs this substance, which by exposure to air, is re-oxidised to indigo blue, thereby rendered insoluble and fixed permanently in the fibre. Artificial indigo may be substituted for natural indigo with advantage.

TINTING EGYPTIAN SHADES.

The colours used for producing the shade of Egyptian cotton on American yarns have already been mentioned. These colours require using with very great care, as many cases of damage have been caused by manufacturers using dyes which were unsuitable for the purpose. A great deal depends upon the treatment the cloth is to be subjected to after it leaves the manufacturer. If it be intended to be sold and used in the unbleached state, then mixtures of chloramine yellow and benzo-chrome brown G. are suitable; the quantities and the proportions of the dyes depending upon the shade required, and upon the percentage of size to be put on the yarn. The above colours, however, are not suitable for goods which have to be

bleached, as they cannot be entirely removed in the bleaching operations. After bleaching, the cloth does not retain the same shade as it possessed before, but it is not possible to get a white cloth if either of these dyes are present. Cases are not unknown where manufacturers have tinted American twist with mixtures of benzo-chrome brown and chloramine yellow with the intention of deceiving the merchant. When the cloth has been bleached the weft has come up white whilst the twist has been tinted. The consequence of this is that the cloth has been entirely spoiled for the purpose for which it was required.

A case which came under the writer's notice, and one in which the manufacturer had been practising this deception, illustrated the maxim that a little knowledge is a dangerous thing. In this case the manufacturer was making a satteen cloth, the selvedge of which contained cotton and worsted twist. The worsted was a bleached yarn, and it was introduced in order that when the cloth was scoured, *i.e.*, half bleached, and afterwards dyed with aniline black, the selvedge would have the appearance of a check pattern. This is possible in aniline black dyeing, because the woollen fibre does not "take" the dye in this process, and in consequence comes up white.

The manufacturer was under the impression that those colours, known as substantive colours, would not dye wool fast shades, and concluded that if he

used this class of colours for tinting his size in order to get the shade of Egyptian cotton on the twist it would be alright. He did not know that many of the substantive colours will dye wool, and the consequence of this was that he used benzo-chrome brown and chloramine yellow, with the result that when the goods were bleached, the wool, which should have been white, came up yellow. It would not have mattered in this case about the cotton coming up yellow after bleaching, as the aniline black would cover it, but it mattered very considerably about the worsted having a yellow tint. As a matter of fact the worsted yarns ought never to have been passed through a tinted size, but should have been sized in a separate "sow" box.

In such a case as quoted, where worsted yarns were used in the selvedge, it would not have done to have used any of the basic colours, as these colours are fast on woollen fibres. Basic colours may be used where the cloth is entirely composed of cotton, and where it has afterwards to be bleached white.

As previously stated, the proportions of the dyes required for giving any particular shade of Egyptian cotton depends upon the amount of size to be put on the yarn. It would therefore be useless to give a standard mixture.

It is necessary to call attention to one serious drawback to tinting the yarns during the operation

of sizing. If the tape frame be stopped, a larger quantity of dye is absorbed by the yarn where it has remained in longer contact with the size. This will show as a brown stain across the piece when the cloth is woven. This difficulty occurs also when the tape frame is run on the slow motion, although the depth in shade is not so marked as when the machine is stopped altogether.

It is hardly possible to avoid this objectionable result. The only thing to do would be to raise the yarn from the size when the machine is stopped (if this were possible), and also avoid running on the slow motion as much as possible.

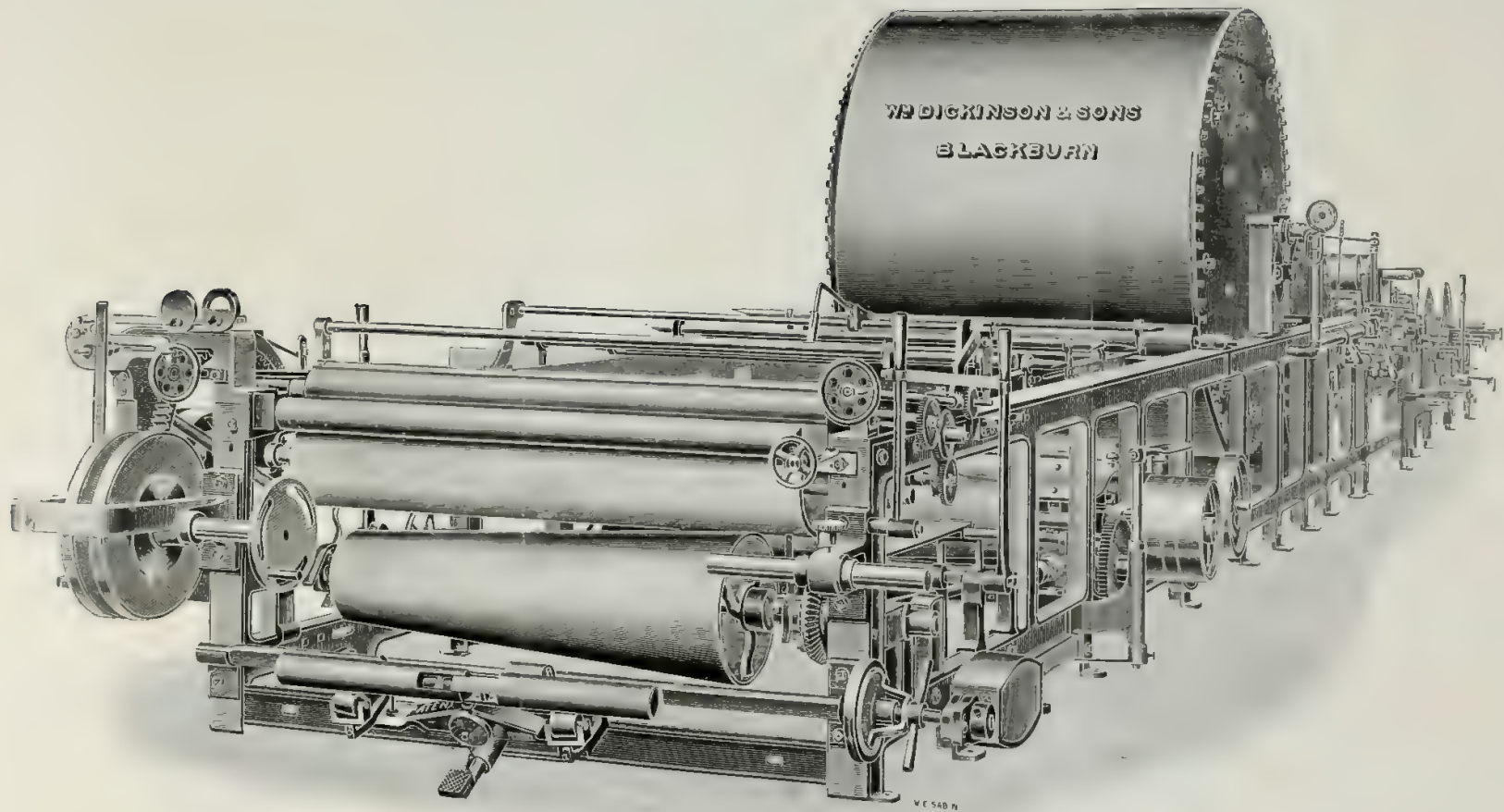


Plate XII. THE TAPE FRAME.



CHAPTER VIII.

Tape-Sizing.

THE TAPE FRAME.

TAPE-SIZING is the principal method used in the cotton trade for incorporating the size with the yarn, and the tape-frame, or slashing machine (*see plate xii.*), is the most important machine used in the preparation of the yarn for weaving. It consists of the following principal parts:—

1. THE CREEL, for holding the back beams.
2. THE “Sow” Box, wherein the size is boiled and put on the yarn.
3. THE CYLINDERS, for drying the sized yarn.
4. THE HEADSTOCK, which is made up of a variety of motions and of appliances, the latter of which are used for:—
 - (a) Cooling the yarn.
 - (b) Separating the threads from each other.
 - (c) Marking off the desired length.
 - (d) Winding the yarn on a beam in a uniform sheet of the required width.

THE CREEL.

The creel is formed from two duplicate cast-iron frames upon which are bolted the beam brackets. The frames are bolted together with wrought-iron

stay-rods. The beam brackets are arranged on two levels, so that the first, and each alternate beam, is on the lower level, whilst the second, and each alternate beam, is on the higher level. Where there is sufficient room it is advisable to have the beam centres a fair distance apart and the position of the even-numbered beams low. This arrangement saves unnecessary lifting when putting in a "set," and at the same time prevents the upper beams overhanging the lower ones.

THE SIZE, OR "SOW" BOX.

The size or "sow" box may be constructed from a variety of materials. Some "sow" boxes are made entirely of cast-iron, whilst others are constructed with cast-iron ends, and with the bottom, front, and back made of pitch pine. Occasionally this form of "sow" box is lined with sheet copper in order to prevent the boiling size injuring the wood-work. Copper linings may protect the wood-work but there is always the danger of the copper being attacked by the chemicals in the size. This might be more objectionable than the damage to the wood. It is certainly a cause of irregular shades in the colour of the woven cloth. Where a copper lined "sow" box is in use it will be found that the size which had been left in the box overnight is tinted green, and the authors know of many cases where this green size has produced a distinct green

shade on the first beam of a day's work. The chief source of this trouble is the presence of acid in the size. This may be due either to rancid tallow, acid flour, or acid in the chloride of zinc. There is no doubt that a copper lined "sow" box is more easily cleaned than a wooden one, and this is of great advantage where it is the practice to tint the yarns, a practice which is fairly common at the present day. The coloured size can be easily cleaned from a copper lined "sow" box, whereas if a wooden box be used the dye is certain to impregnate the wood and it can be entirely removed only with difficulty. If, instead of using copper for the "sow" box lining, lead or zinc were employed in its place, none of the ill-effects just mentioned would be produced.

There are many different opinions as to the form the "sow" box should take. The authors advise the use of a deep box in preference to a shallow one. The former holds more size and on this account permits the size being boiled for a longer time before it comes in contact with the yarn. Another advantage is that the steam, issuing from the boil pipes, has a greater distance to travel before reaching the surface of the size. It thus gives up more of its heat in its passage through the size before being liberated at the surface.

The "sow" box is fitted with the following essential parts:—Feed Pipe, Boiling Pipes, Float

Roller, Immersion Roller, Copper Roller, Finishing Roller, Guide Rollers, and Falling Roller.

THE FEED PIPE.—The feed pipe, which should be sufficiently long to go across the “sow” box, should be placed a few inches from the bottom and about the same distance from the back of this box. It should be perforated at equal distances with a row of holes, the number depending upon the class of sizing. For “pure” sizing 6 holes will be sufficient and these should have a diameter of $\frac{1}{8}$ of an inch. For “medium” and “heavy” sizing from 9 to 12 holes of varying diameters will be necessary. The first hole, *i.e.*, the one at the feed end of the pipe, should have a diameter of $\frac{1}{8}$ of an inch, as for “pure” sizing, whilst the others should increase in size gradually to $\frac{1}{4}$ of an inch. These holes should be set facing downwards and backwards. If the feed pipe be arranged in the manner described the size will be delivered evenly across the “sow” box, and, at the same time, as far as possible away from the place where it comes in contact with the yarn.

THE BOIL PIPES.—The boil pipes are constructed from two straight copper tubes with an internal diameter of one inch. These pipes should extend the full width of the box. Each pipe should be fitted with a separate $\frac{3}{4}$ -inch tap to enable the taper to regulate the amount of steam to his requirements. In many cases the steam is supplied to one end of

each pipe only. This arrangement is not the best as it tends to produce a variable "boil" owing to the steam decreasing in pressure as it gets further away from the supply. A better way is to extend each boil pipe through both sides of the "sow" box and to couple up the steam supply at each end.

The holes in the boil pipes should be arranged in two rows. If the boil pipes are arranged to rest upon the bottom of the box the two rows of holes should be drilled exactly opposite to each other, and care should be taken that the pipes are so fixed that the holes are set in a direction parallel with the bottom of the box, otherwise one row of holes may be facing upwards, and the other downwards. This would cause the steam issuing from the lower row to quickly blow a series of holes through the wood-work of the "sow" box, unless it were lined.

The best method of arranging the boil pipes is to place them a few inches from the bottom of the "sow" box. The holes can then be drilled below the axis of the pipe, and, although both rows of holes are slightly inclined towards the bottom of the box, there is not the same danger of injuring the wood-work on account of the depth of size which intervenes between the exits of the steam and the wood-work of the box. Another advantage of this arrangement is that there is not the same tendency for the holes to get made up.

THE FLOAT ROLLER.—The float roller, which is connected with the self-feed valve, is used for the purpose of regulating the amount of size entering the “sow” box. It consists of a hollow copper roller, one end of which works in a fixed bracket, whilst the free end works in a vertical “guide.” The free end of the roller thus rises and falls according to the depth of size in the “sow” box in the same manner as the “ball float” used for regulating the water supply to a bath cistern. One end of a brass or copper lever is fixed vertically to the free end of the roller, the other end of this lever being attached to the horizontal lever of the self-feed valve. Usually a number of holes are drilled through the vertical lever at the end which is attached to the self-feed valve lever. These holes are for the purpose of allowing the taper to regulate the height to which the size will rise in the “sow” box before the supply is cut off by the combined action of the float roller and the self-feed valve. The attachment of the float roller lever to the self-feed valve lever should be so adjusted as to allow the “sow” box to be worked as full as possible, without incurring the risk of boiling a portion of the size on to the sheet of yarn when the requisite amount of “boil” is being used.

THE IMMERSION ROLLER.—The immersion roller, as its name implies, is used for the purpose of immersing the yarn in the size.

It is generally believed that a greater quantity of size is put on the yarn when this roller is well immersed. This may be so for “pure” sizing but for “medium” and “heavy” sizing it makes very little difference whether the roller is entirely immersed or not. The point at which the size is actually put on the yarn is where the copper roller and the finishing roller meet. Therefore, if the size be kept at a sufficiently high level in the “sow” box to ensure that the copper roller is entirely covered with size from the point where it leaves the size, to the point of contact with the finishing roller, it is practically immaterial where the immersion roller is placed so long as it gives a level sheet free from “half beers.”

The reason it is advisable to lower the immersion roller until the yarn is immersed in the size, in the case of “pure” sizing, is owing to the size being much thinner, and less viscid, than that used in “medium” or “heavy” sizing. In consequence of this it does not adhere to the copper roller the same, but runs quickly off leaving places uncoated with size. This would cause soft places on the weavers’ beam ; a most objectionable condition.

Many forms of skeleton immersion rollers have been placed on the market at one time or another. It is claimed for them that they enable the yarn to be immersed on *both sides* (if a cylindrical thread can be said to have sides)! So far as the authors can see these rollers possess no advantage over the

old style of roller. They do not enable the size to enter the yarn with greater ease or uniformity, and they are far more likely to do harm than good in other ways.

The immersion roller should be set about one-eighth of an inch away from the copper roller, and parallel with it when they are wound down to a position where their centres are opposite each other.

THE COPPER ROLLER.—The copper roller is the most important roller about the tape frame and no machine can turn out satisfactory work with an imperfect one. This roller consists of a copper shell fitted to a good strong shaft running through the middle. The copper shell should be from three-eighths to half-an-inch in thickness when new. Wide rollers are subject to a certain amount of deflection from a true circle when heated, owing to the difference in the rate of expansion between the copper shell and the wrought-iron shaft upon which it revolves as a centre. This tendency to buckle is more pronounced as the width of the tape frame increases, or the thickness of the copper roller shell decreases. Attempts are made to remedy this defect by having one or more mid-feathers turned up to fit inside the copper roller. A much better plan is to have an expansion joint fitted on the shaft.

The copper roller requires careful treatment and too much care cannot be exercised by the “taper” when cutting “lappers” off. Unless care

be exercised the surface of the roller, especially at the sides, will soon be injured by the point of the knife blade making deep scratches on it. These scratches have a tendency to nip the yarn as it passes over them, and in this way more "lappers" are formed than would otherwise be the case. By careful usage, and by the periodical application of fine emery cloth to the surface of the copper roller, it is possible to make this roller work for years, and at the same time to reduce "lappers" to a minimum without any necessity for having its surface turned true in a lathe.

THE FINISHING ROLLER.—The finishing roller is a heavy cast-iron shell fitted with wrought-iron ends. It generally weighs from six to seven pounds per inch of length. A heavy roller is essential to obtain a good finish, particularly in heavy sizing. Before being put into use the finishing roller should be painted, or coated with oil, in order to minimise corrosion. It should then be "lapped," first with a fent, and afterwards with flannels of some description. Over the flannels a cotton cloth fent should be "lapped." The object of the flannels and the fent is to provide a level yielding surface to the roller, thus enabling it to squeeze the superfluous size from the yarn as it passes between the copper roller and the finishing roller, without injuring it.

There is a diversity of opinion as to the best kind of flannels to use for the finishing roller. Some

prefer them made from wool, both warp and weft, whilst others prefer a union containing either a cotton or a linen warp, with woollen weft. For economy and general use the authors prefer a linen warp union for the bottom flannel, and a cotton warp union for the other two. Each flannel should be four yards long when supplied to the taper.

The objection to all-wool flannels for heavy sizing is that they are apt to slip when a new flannel is put on. In some cases the slipping occurs to such an extent that the flannels will continue to revolve when the finishing roller is stopped. Cotton unions are not subject to this fault, and they undoubtedly last longer than those which are all wool. The bottom flannel should be the strongest and for this reason a linen union is preferred.

Some of the ingredients used in sizing have a tendency to corrode the outer surface of the finishing roller. This corrosion does not occur evenly, and in consequence it becomes necessary to "turn up" the roller in a lathe periodically, in order to preserve a true circular surface. This "turning up" reduces the roller very considerably in weight each time the operation is carried out. This loss in weight must be regained, and it is the practice to attach weights to the ends of the roller. This is not the best way of overcoming the difficulty. A better way is to remove the end of the roller and fill the hollow

shell with iron borings. In this way 100 pounds can often be added to the weight of the roller and the distribution of the added weight is much more uniform than would be the case if weights were suspended, or attached to one or both ends of the finishing roller.

The practice of allowing the finishing roller to run as long as possible before stripping is false economy. Nothing looks more unworkmanlike, or produces worse work, than the presence of patches of fents of various widths and thicknesses on this roller. In order to secure a good level foundation the finishing roller ought to be stripped three or four times a year. This minimises the tendency of the iron rust which forms on the roller corroding more than the bottom flannel.

If finishing rollers were made with a thin brass or copper sleeve over the iron shell it is probable that a better average finish would be obtained, and less damage would be done to the flannel through corrosion.

Great care should be exercised in lowering the finishing roller on to the copper roller, as the shaft in the latter can be easily strained if the finishing roller is dropped abruptly on account of its heavy weight.

Some "sow" boxes are constructed with two copper and two finishing rollers. In the opinion of the authors no good purpose is served by this

device, because sufficient size can be put on the yarn for any class of sizing and as good a finish can be obtained with one copper roller and one finishing roller as with two of each.

THE MID-FEATHER.—The mid-feather is a wooden partition dividing the “sow” box into two compartments. The partition should be arranged so that there may be a free flow of size from one part of the box to the other. This may be done either by cutting a number of holes in the lower portion of the mid-feather, or by raising the mid-feather by means of two feet, one of which should be fixed at each end of it. These feet should stand about three inches in height, so that there is a space of three inches between the mid-feather and the bottom of the “sow” box for the size to flow through.

The addition of a mid-feather may be an improvement in “pure” sizing where a pan is not used for boiling the size previous to its entering the box, but if a boiling pan is used the advantages to be derived from a mid-feather are more imaginary than real.

THE FALLING ROLLER.—The falling roller rests on the sheet of yarn between two guide rollers, whose centres revolve in brackets fixed on the “sow” box sides. The whole arrangement is placed between the back-beams and the immersion roller. Each end of the falling roller works in a

perpendicular bracket having a long slot in it. Any slackness of the yarn, caused by the back-beams running irregularly, or produced when the machine itself is stopped, can thus be corrected by the weight of the roller as it descends in the slot.

The other fittings of the "sow" box are not matters of great importance, and they do not require detailed description. It is perhaps well to state that it is better to have a copper lid for the "sow" box rather than a wooden one, and also that it is advisable to have a large tap for the purpose of drawing off the contents.

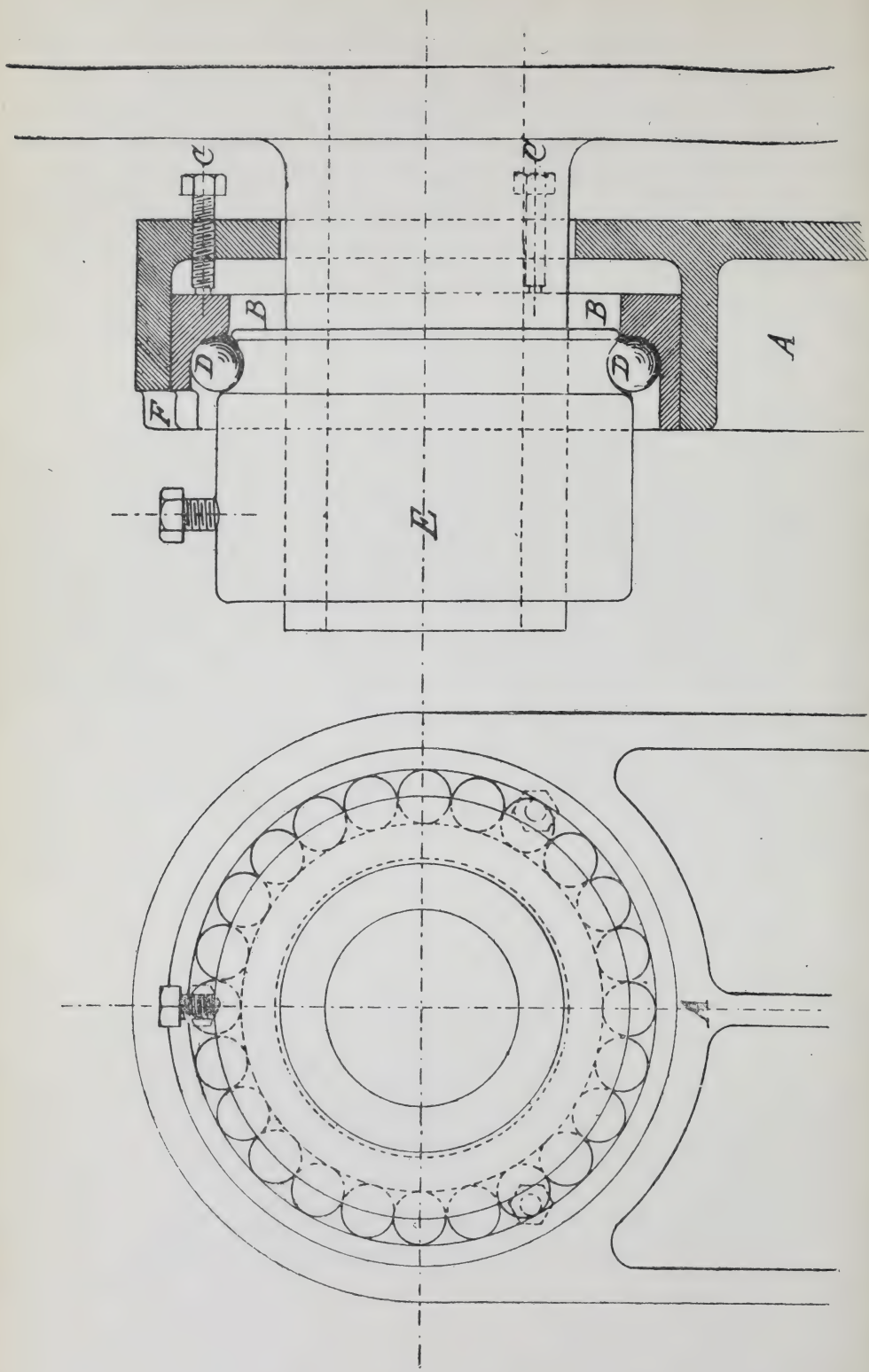
THE DRYING CYLINDERS.

It is usual to have two drying cylinders in a tape-frame. The diameters of the cylinders in common use are 6 feet and 4 feet; 7 feet and 4 feet; and occasionally 7 feet and 5 feet.

WIDTH OF CYLINDERS.

Width of Machine.	Width on face of Tin Cylinder.
9/8's	60 inches.
6/4's	66 "
7/4's	72 "
8/4's	78 "
9/4's	84 "
10/4's	90 "

It is not necessary to go into details regarding the construction of the drying cylinders except to



Ball-bearing Arrangement for Reducing the Friction of the Cylinder Trunnions.
Wm. Dickinson & Sons, Blackburn.

point out the desirability of having double-acting buckets in them. By this arrangement the condensed water can be removed whichever way the cylinders are put in, or whichever way they are rotated. These buckets will also prove useful if it be desired, when sizing coloured bordered goods, to run the coloured yarn next to the surface of the big cylinder instead of on the top of the grey yarn. In the former arrangement the cylinder would revolve in a direction opposite to that in which it would revolve in the latter, as shown in the diagram under coloured tapeing.

In order to reduce the friction of the cylinder trunnions to a minimum, Messrs. Wm. Dickinson & Sons, Machinists, Blackburn, have devised a ball-bearing arrangement. An illustration of this is given on page 328. It consists of a stand A, which is bolted to the top of the frame sides. This stand is machined inside so that the turned steel ring B fits easily into it. This ring is adjustable from behind by means of the three set screws C and encases the steel balls D. An adjustable outer collar E helps to keep the balls in their proper position, thus giving correct guidance to the trunnions without undue pressure on the steel balls. The insertion of the balls is easily accomplished by setting the collar E at the required distance from B, to allow the balls to be dropped through F. When a sufficient number of balls have been inserted the

collar E is pushed inwards into easy contact with the balls and fixed by means of the set-screws.

The "taper" should see that the friction bowls upon which the cylinder trunnions rest are kept in efficient working order. If yarn and dirt be allowed to get entangled with them, and if oiling and cleaning be neglected, they will either revolve irregularly or cease to revolve at all. This must inevitably increase the power required to turn the cylinders and, at the same time, increase the tension on the yarn in a corresponding ratio. The consequence would be that a large amount of the natural elasticity of the yarn would be taken out at this point instead of being retained for the process of weaving. Unnecessary tension may be caused also by too tightly screwing the glands of the stuffing boxes.

STEAM TRAPS.—Each cylinder should be coupled to a separate steam trap, fitted with a small tap, in order to allow the cold air to escape when steam is admitted.

Steam traps are constructed in a variety of ways. In some forms the lid of the trap can be taken off, and the ball, or valve, adjusted whilst the machine is working. Traps constructed in this way require the beck or cistern into which they discharge the condensed water to be placed on a lower level than the trap.

It is customary in some districts to have a small force pump, driven from the side shaft, for the

purpose of pumping the water from the steam trap to any desired level. In the majority of cases the pump could be dispensed with if a suitable steam trap were used. The trap should be of such a form that the pressure of the steam is exerted on the water in the trap. This would force the water from the trap and a lift of two feet per pound of steam pressure could be obtained.

THE HEADSTOCK.

The headstock consists of a variety of motions, the most important of which will be briefly described.

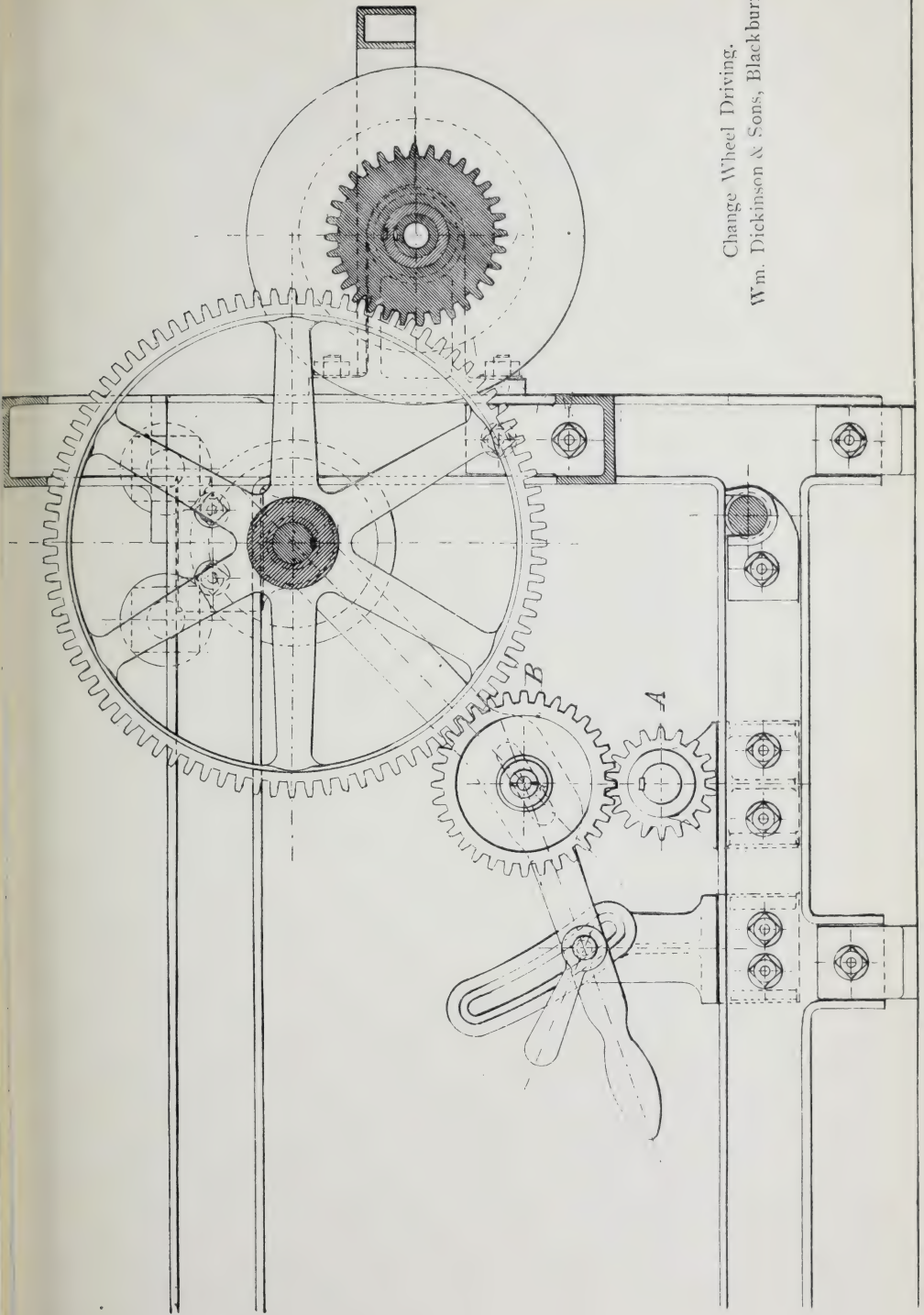
THE DRIVING MOTION.—The driving arrangement may be carried out by means of cone drums, change wheel driving, or by a combination of both.

CONE DRUM DRIVING.—Cone drum driving is undoubtedly the best arrangement in many ways. It enables the taper to make slight but important alterations in the speed at which the tape frame is running, and the machine can be started with less risk of a jerk. At the same time cone drum driving is not an ideal mechanical motion, as each portion of the drum runs at a different speed from the rest throughout the whole of its length. This accounts for the trouble experienced by many “tapers” of having a cone drum strap continually slipping. This is especially the case when the weaver’s beam is nearly full, or if extra “press” is being used.

It appears to the authors that a considerable amount of this troublesome defect in cone drum driving might be avoided if "slashing" machine makers would make the drums as long as possible, and thus reduce the gradient of the tapered portion. If this were done a more uniform speed of the space covered by the cone drum strap would be attained. The diameter of the drums might be considerably increased in many cases. This would increase the linear velocity of the cone drum strap, with a proportional decrease of the "pull" required to be exerted by it. The speed of the driving cone drum might be increased also, with a corresponding decrease in the number of teeth in the small pinion which drives the draw roller wheel. This would further reduce the tension on the cone drum straps, and they would still be transmitting the same amount of work, but at a greater velocity.

One of the simplest and most effective methods of remedying a slipping strap (where a single one is used) is to take the strap forks off, and replace them with forks to hold two or three narrow straps, in place of the original wide one. Two straps, each two inches in width, will give a far more satisfactory drive than a single four-inch strap. Slipping of the strap can also be prevented by having two straps running one on the top of the other, the top strap being narrower than the under one. These straps do not retain the same relative position to one

Change Wheel Driving.
Wm. Dickinson & Sons, Blackburn.



another when running owing to the different speeds at which they travel.

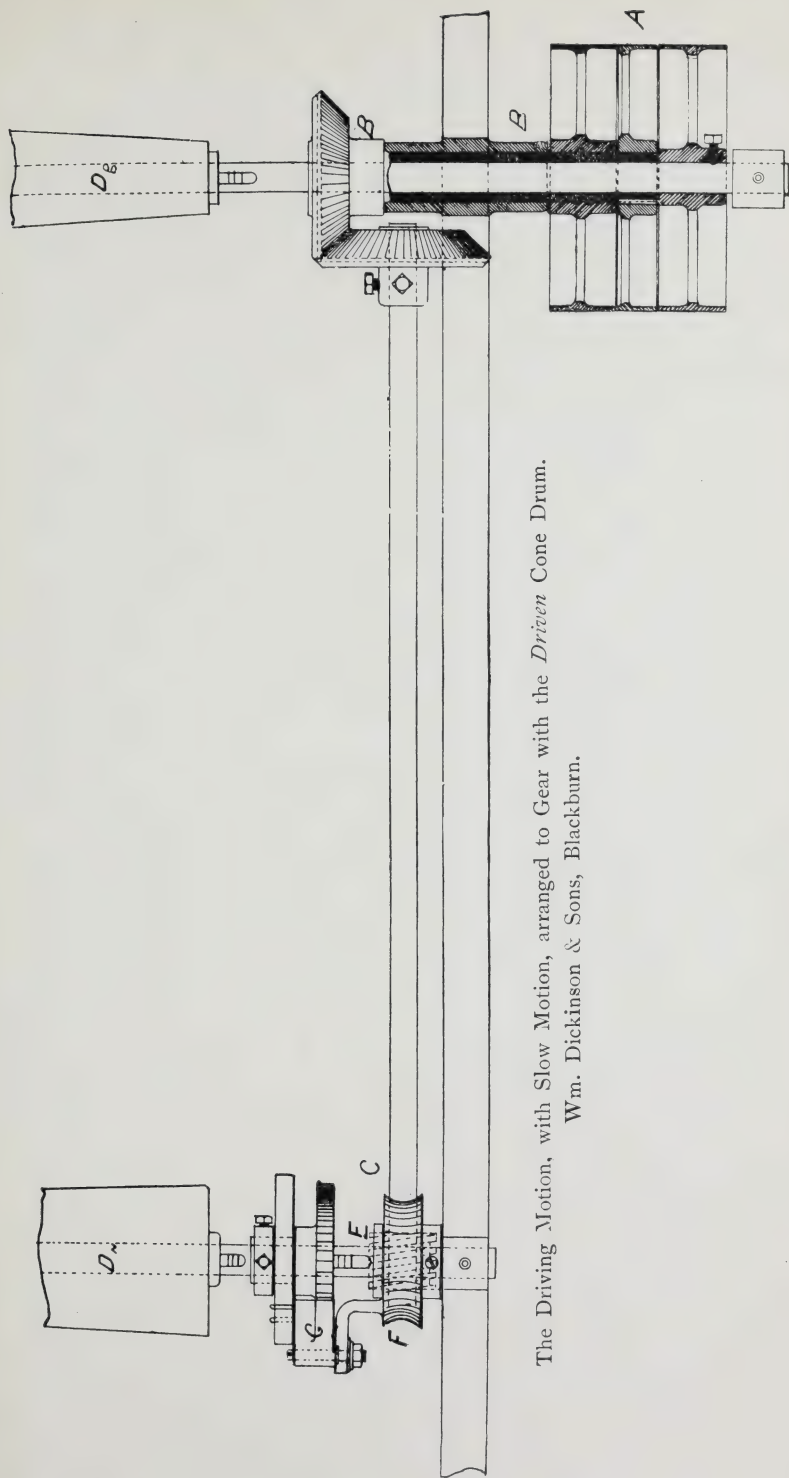
CONE DRUM AND CHANGE WHEEL DRIVING.—In this form of driving the length of the drums may be considerably reduced. With this arrangement small variations in speed could be made by altering the position of the cone drum straps, but greater variations would require an alteration of the “change” pinion.

CHANGE WHEEL DRIVING.—An illustration of change wheel driving will be found on page 333. A is the change wheel pinion whilst B is an adjustable carrier wheel which transmits the motion of A to the draw roller wheel.

SLOW MOTION.—An auxiliary to the driving motion is the slow motion, by means of which the frame can be run at a very low speed. This arrangement is necessary in order to avoid producing stiff places on the yarn. The stiff places are caused by the heat of the copper roller baking the size on the yarn when the frame is stopped for any length of time.

The slow motion should be arranged to gear with the *driven* cone drum as shown on page 335, otherwise it is useless when the cone drum strap slips or breaks.

The arrangement for converting the *driven* into the *driving* drum, when the slow motion is being used, is as follows :—



The Driving Motion, with Slow Motion, arranged to Gear with the *Driven* Cone Drum.
Wm. Dickinson & Sons, Blackburn.

The fast pulley, shown with a set-screw in it, is fastened to the driving cone drum shaft. The lengthened boss, B, of the narrow slow motion pulley, A, carries a bevel wheel and this drives the short side shaft C. Shaft C, by suitably proportioned worm and wheel gear, E.F., and click motion, G, engages with the ratchet wheel on the shaft to which the driven cone, Dn, is fixed, as soon as the speed of the latter is on the point of falling below that which the slow motion is calculated to give.

The change of speed is gradual and automatic and is never allowed to fall below the rate at which the slow motion is intended to run.

The arrangement of the three pulleys on the driving shaft allows, by the continued one way movement of the "setting" on levers, the starting of the machine, first to slow, and then to full speed. This is preferable to the old system where the loose pulley occupied the middle position.

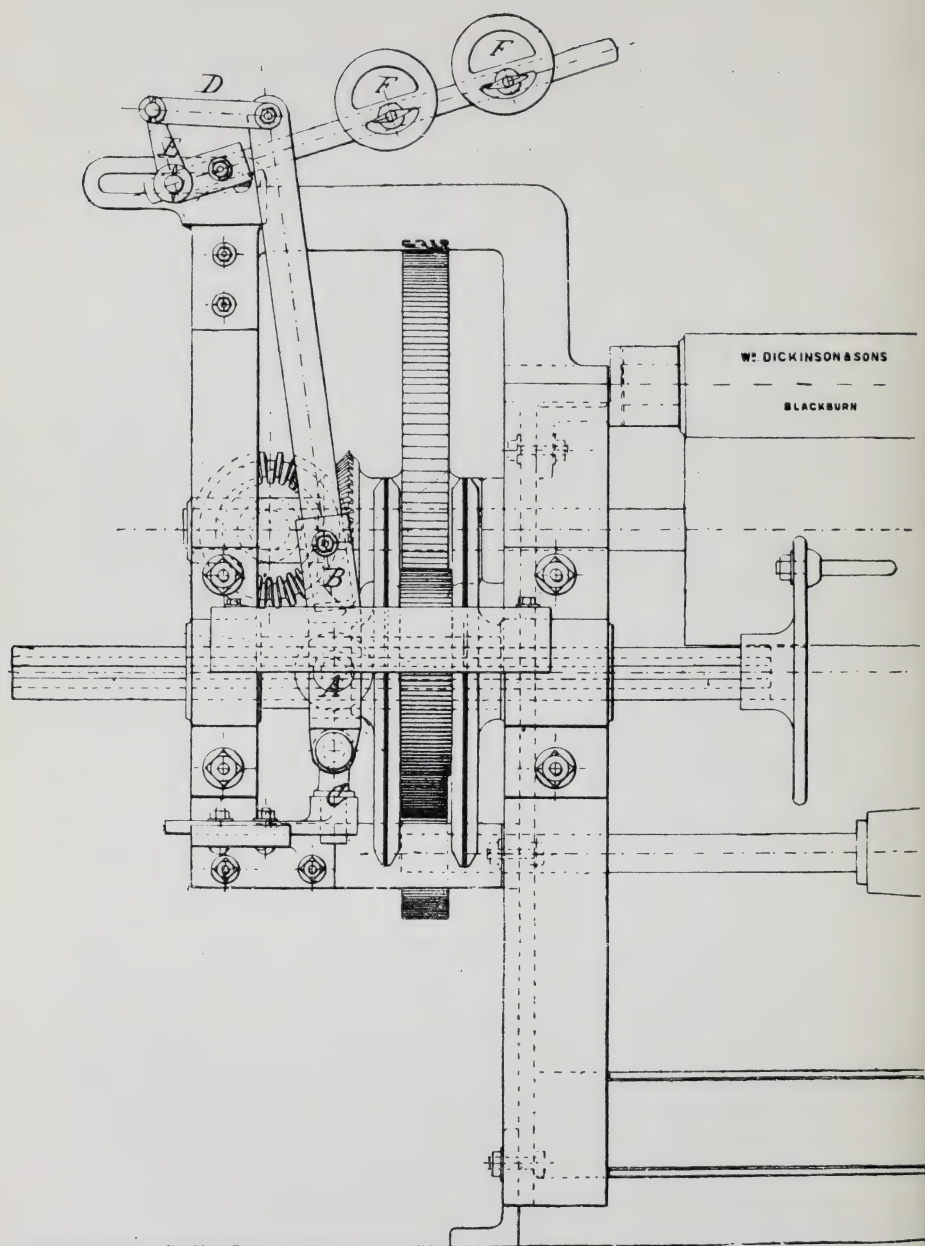
THE FRICTION MOTION.—This motion is for the purpose of winding the yarn which is delivered from the draw roller at a uniform rate on to the weaver's beam. This beam is constantly increasing in circumference and it thus requires to make a correspondingly decreased number of revolutions to wind on a given length of yarn.

The "winding on" of the yarn ought to be the sole duty of the friction motion. It should be adjusted so as to turn the beam round without setting

up any unnecessary tension on the yarn between the point where it is delivered from the draw roller to the point where it begins to wind on the weaver's beam. The authors know of cases where it is the practice to produce a hard weaver's beam by increasing the amount of tension on the yarn. This method cannot be too strongly condemned. The proper way to increase the hardness of a beam is to increase the weight on the press lever. The tension on the yarn should always be reduced to the lowest workable amount when winding it on the weaver's beam, thus retaining as much of its elasticity as possible for the process of weaving. This matter has been mentioned previously when discussing the drying cylinders.

It is advisable to pull the friction motion to pieces periodically. The plates and flannels should then be examined and any substances such as rust, dried oil, or dirt, should be carefully removed. This will prevent irregular working.

A modern friction motion will be found on page 338. The anti-friction bowls, A, carried by the lever, B, press upon the friction plates. Lever B is fulcrumed upon the swivel C, so as to allow the bowls to follow any deflection or variation in the plane of rotation of the friction plates. The upper end of lever B is connected by the link D to the bell crank lever E, the longer arm of which carries one or more weights F. These weights are



The Friction Motion.

secured by thumbscrews, so that they can be easily moved as more or less tension is required.

When changing the weaver's beam the lever carrying the weights is turned up. This removes the friction from the plates and enables the "taper" to move the mandril shaft with ease.

It may be advisable to point out that the alterations in speed of the weaver's beam, necessarily involved by the circumference of the beam increasing with each successive layer of yarn, are governed *entirely* by the friction motion. The usual explanation given in text books, "that these alterations are due to altering the position of the cone drum strap," *is wrong*. In all modern machines the movement of the strap along the cone drums increases or decreases the speed of the machine as a whole. The gradual decrease in the revolutions of the weaver's beam is due to a corresponding increase in the amount of slipping which takes place between the plates and flannels of the friction motion.

Another erroneous idea is, that after fixing the weight on the friction lever to obtain the desired tension for the first beam of a "set," no further alterations are required until the "set" is finished. In good "tapeing" practice the weight on the lever should be reduced to a minimum at the commencement of a beam, and it should be increased as the beam gets larger. This is essential to overcome the extra power required to turn the beam as it increases

in weight. The leverage exerted on the beam by the press also increases with the size of the beam. If the weight be fixed in such a position as to turn the beam when full with plenty of "press" on, the tension at the beginning with the weight in the same position would be sufficient to break some of the "ends." The elasticity of the unbroken "ends" would also be reduced to such an extent as to make an appreciable difference in the weaving.

THE DRAW ROLLER.—The draw roller is a "built up" wooden roller having a wrought-iron shaft in the centre upon which it revolves. Two heavy iron rollers, known as the "nip" rollers, rest on this roller. The three rollers are used for the purpose of pulling the yarn from the cylinders and delivering it to the weaver's beam. The draw roller derives its motion, by means of a spur wheel, from the small pinion on the end of the driven cone drum shaft. It is also geared with the copper roller by means of two pairs of mitre wheels on the side shaft. The object of the side shaft is to relieve the tension on the yarn by having it delivered to the cylinders positively, and taken from them in the same way. The yarn is thus relieved of considerable tension in comparison to the amount to which it was subjected previous to the introduction of the side shaft. It is still possible, however, even with the above arrangement, to subject the yarn to undue tension if the circumferences of the draw roller and of the

copper roller are not kept in the right ratio. The circumference of the copper roller is constant, but the draw roller is "lapped" with several rounds of flannel in order to prevent the yarn being injured by the nip rollers which revolve on the top of it. In addition to the flannel, cotton fents are wound round the roller, and it is thus possible to stretch the yarn to a considerable extent if too many be used.

Where tapers are on piece-work there is a desire to get through the work quickly, and this can be managed by putting extra fents on the draw roller, the effect of which is to tighten the yarn round the drying cylinders. This makes it dry more quickly owing to its being brought into closer contact with the hot cylinders, thus allowing the frame to be run at an increased speed. This speed however, is obtained at the expense of the elasticity of the yarn owing to its being kept too tight between the copper roller and the draw rollers.

Any extra tension can be readily detected by an experienced eye if the amount of deflection of the sheet of yarn from a straight line, as it travels from the copper roller to the top of the big cylinder, be noted. If the yarn does not sag between these points it is direct evidence that it is too tight.

Sharp practice of this description should be stopped at once, as the natural elasticity of the yarn ought to be retained as far as possible through all the preparatory processes.

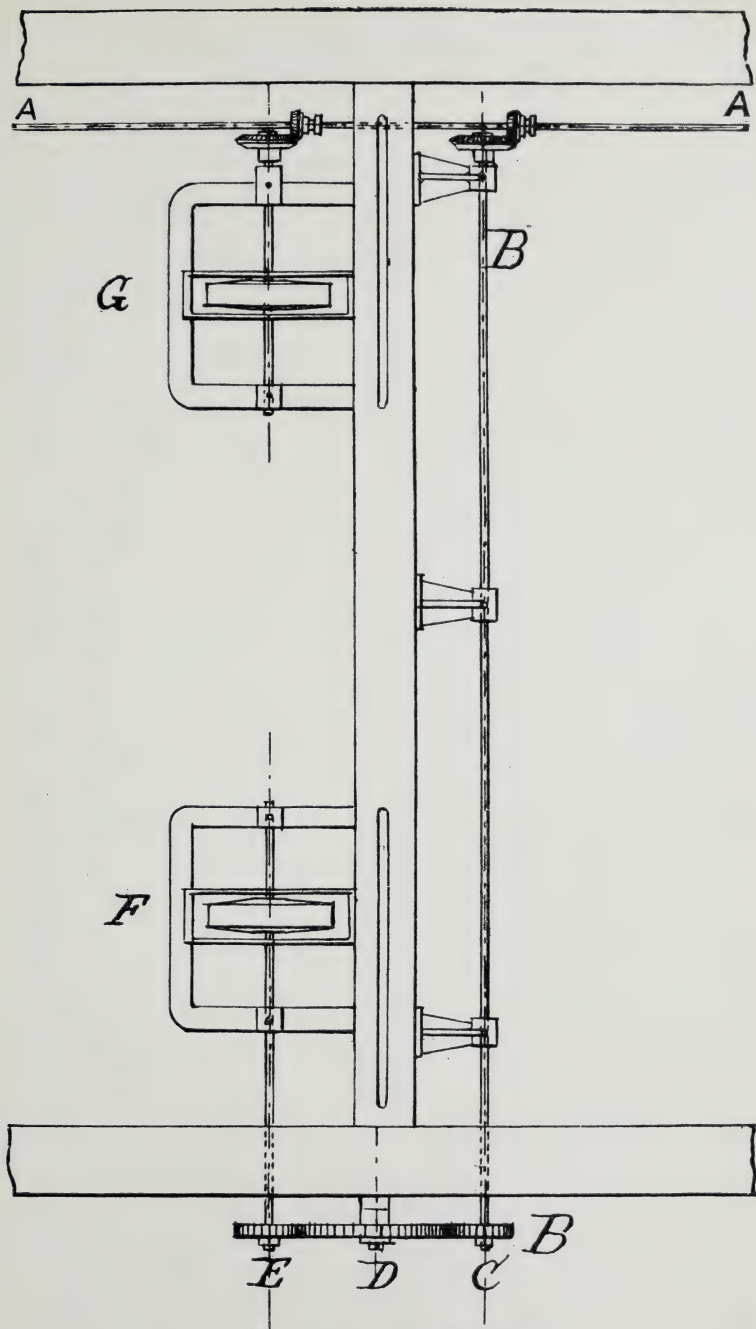
THE MARKING OR MEASURING MOTION.—This arrangement is used for the purpose of marking off the yarn to the required length. There are a variety of motions for attaining this object. Some tape frames are fitted with one marker only. Where there are a number of marks in a piece of cloth the weaver is expected to count them as they “weave in,” and finish the piece at the right one. The counting can be avoided by having two markers, commonly known as “dhootie marking motion.” A motion of this description is shown on page 343.

A is what is known as the bell wheel shaft. It derives its motion from a train of wheels actuated by the measuring roller. The dhootie marker G is driven from the bell wheel shaft by means of a pair of bevel wheels. The cut marker F is also driven by it through the wheels E, D, C, and the cross shaft B.

The bell wheel shaft A can be controlled by a small wheel at the front of the headstock. This enables the taper to set the marking cams at the commencement of a weaver's beam to the desired position.

The ratio of the number of “marks” made by the dhootie and “cut” markers depends on the number of the teeth in the wheel C and E. The wheel D is simply a carrier used for transmitting the motion of C to E.

In weaving dhooties it is of the utmost importance that the headings be inserted exactly at



Dhootie Marking Motion.
Wm, Dickinson & Sons, Blackburn.

each side of the mark. This is to ensure that the scarves shall be of uniform length, as buyers object to varying lengths. These objectionable variations are due to the weaver allowing the "mark" to "weave in" before inserting the "headings," or "middling" as it is termed.

In order to reduce the number of "marks" "woven in" some machines are fitted with three markers. Two of these are on the dhootie marker shaft, and one of them is usually set so as to make a mark a few inches before the other, and usually of a different colour. The object of this arrangement is to warn the weaver of the approach of the "mark" requiring a "middling," when the first, or pilot mark, is seen "weaving in."

A three "mark" motion can be used also for running alternate marks of unequal lengths. If it be required to make a mark in every four yards, followed by one in every three yards, the measuring roller wheel and stud wheel are arranged to give a mark every seven yards on the dhootie marker shaft. The two marking cams can then be set in such a position that one marker will drop three yards in front of the other.

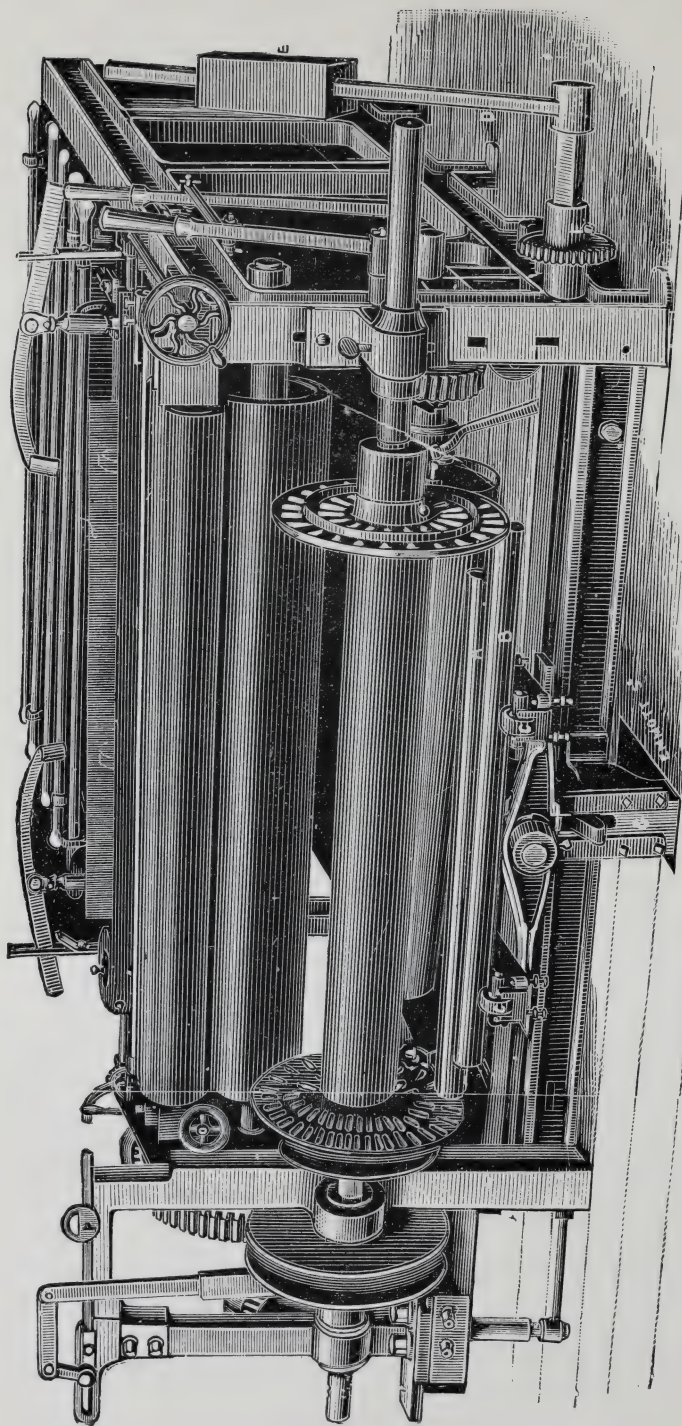
THE PRESSING MOTION.—A pressing motion of some description is fitted to all modern sizing machines. It is used for the purpose of closely pressing the layers of yarn on the weaver's beam. An increased length of yarn can thus

be wound on each beam. This reduces the number of weaver's beams produced from a "set" of backbeams, and on this account reduces the cost of "drawing in." Another consideration is that less beams have to be "gaited" in the weaving shed.

There are a variety of "presses" on the market, some of which have one roller, whilst others have two.

ONE-ROLLER "PRESS,"—One of the latest one-roller "presses" is shown on page 348. In the majority of these "presses" the roller is a few inches narrower than the space between the beam flanges. Suitable mechanism is arranged to impart a traversing motion to the roller, first in one direction, then in the other. In the illustration it will be seen that a single iron roller on the expanding principle is used. This is "set" within two or three inches of the width required and it gradually works itself out until it is in contact with both beam flanges.

Instead of the usual rack wheel and catch, a friction motion as shown in the illustration may be used. This is fixed on the square shaft at the opposite end to the weight. The amount of "press" on the beam can be regulated by increasing or decreasing the pressure on the "friction," as well as by regulating the position of the weight on the "press" lever. The authors have not seen anything to equal this "friction" motion for producing a true



The Headstock. Showing Two-Roller "Press."
Wm. Dickinson & Sons, Blackburn.

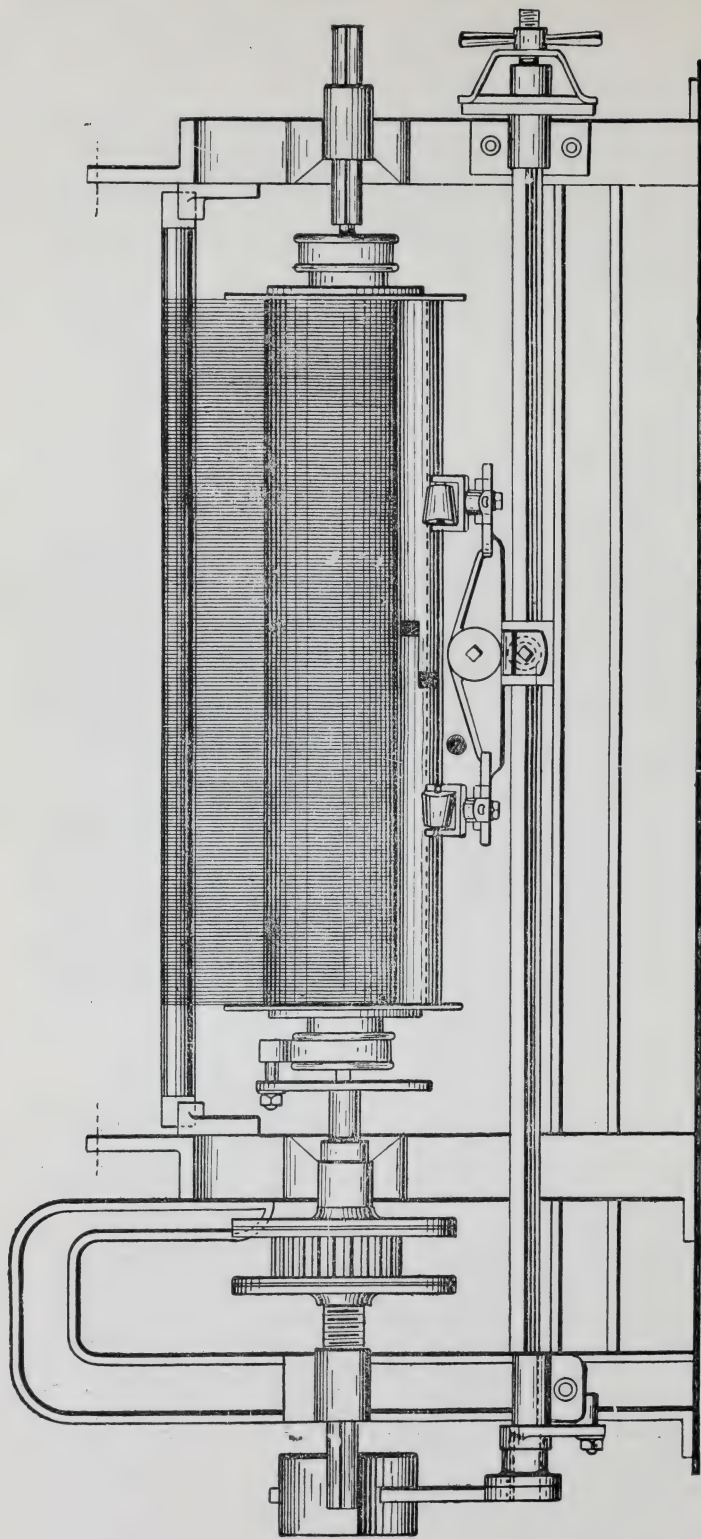
beam on a crooked beam barrel. This friction motion can be applied either to the one or to the two-roller "press."

TWO-ROLLER "PRESS."—The two-roller "press" is arranged to have each roller tending to travel laterally in opposite directions. An illustration of the front portion of a headstock with a two-roller "press," fitted to it is shown on page 346.

The pressing rollers A, B, are adjusted by means of the small screws seen beneath the friction bows C, so that the revolution of the beam will cause one roller to move to one side of the beam until it comes into contact with the inside of the flange. The other roller does the same in the opposite direction so that the whole of the beam is subjected to pressure. The required degree of pressure can be obtained by altering the position of the weight upon the lever D.

Nearly every maker has some special modification of the two-roller "press," but they all have one grave defect, and that is, they have a tendency to scrape the paint off the beam flanges. This is responsible for the majority of the iron-stained selvages produced in the cotton trade.

The ideal "press" roller has yet to be produced and an inventor who can bring out one which will press uniformly across the beam, and produce a true beam automatically without scratching the paint off the flanges, will find a ready sale for it.



One-Roller "Press" with Friction Motion.
Wm. Dickinson & Sons, Blackburn.

The amount of "press" required for beams varies with the "sorts." Beams requiring plenty of weight in the weaving shed should have the maximum amount of weight put on the "press" lever, in order to prevent the sides sinking in when nearing the bottom of the beam. Very heavily sized goods, especially when "taped" damp, require very little pressing.

FANS.—One or more fans are fixed between the place where the yarn leaves the small cylinder and the cone drums. These fans consist of three wooden blades bolted on castings and fitted to a shaft. This shaft is arranged to revolve at a high speed. The fans are used to cool and further dry the yarn after it has left the hot cylinders.

Wheels, which have a fair amount of metal in the rims, are usually fixed on the fan shafts. These wheels serve the same purpose as the fly-wheel in an engine. The power required to start them tends to prevent the machine beginning with a jerk when the driving strap is put on the fast pulley, and the energy stored up in them keeps the machine running a few yards after the strap is taken off the fast pulley.

THE WRAITH.—This is a comb which is placed in front of and parallel with the weaver's beam. It is fitted with iron teeth, each of which is inserted between the coils of a series of spiral springs. The ends of the springs are fastened to a bracket which

also acts as a nut. The two nuts, one of which has a right and the other a left hand thread, are screwed on a rod. By turning the handle at the front of the machine the "taper" can impart a rotary motion to this rod. If the handle be turned in one direction the spiral springs are stretched and all the teeth of the wraith expand equally. If the handle be turned in the other direction they contract. The sheet of yarn "laid in" between the teeth can thus be made wider or narrower as required.

Another motion is fixed to the opposite side of the machine by means of which the wraith can be moved sideways without altering the distances between the teeth. These two motions enable the "taper" to adjust the yarn to the width between the flanges of the weaver's beam.

A small ratchet wheel is usually fixed to one end of the screwed rod. Intermittent motion can be imparted to this wheel by means of a driving "paul" having a reciprocating motion derived from a cam on the driven cone drum shaft. When the yarn on the weaver's beam is within a short distance of the top of the flange the "paul" is put in gear with the ratchet wheel. This causes the wraith to contract and the sheet of yarn gradually decreases in width as each successive layer is wound on the beam. The sides of the sheet of yarn are thus made to slope inwards. By this means a greater length can

be put on a beam without much risk of the sides being damaged.

When the yarn is wound in at the top of a beam as just described it often leads indirectly to what are known in the weaving shed as "crooked beams." Instead of all the "threads" coming off the beam straight and parallel to each other some of them will be crossed at regular intervals across the beam. The beam will look all right and straight when "gaited up," but the ends get crossed by the time the yarn has woven down to the level of the flange. The crossing of the "threads" is caused by the formation of very fine grooves in the "sheeting rollers," which are placed in front of the wraith. Some of the threads of yarn run in these grooves, and when the wraith is being contracted they stick in the grooves whilst the others are being pushed inward by the teeth of the wraith. The ends which stick in the grooves are those which are found "crossed" in the weaving shed. If the sheeting rollers, especially the lower one, are periodically glazed on an emery wheel "crooked beams" will be reduced to a minimum.

For dhootie borders, the teeth at each side of the wraith are made a few inches longer than those in the middle. This is to keep the coloured ends in their places, and it is an essential arrangement on account of the coloured yarn being on a higher level than the grey yarn during the operation of sizing.

The teeth of the wraith should be examined periodically, in order to ascertain whether grooves are being worn in them. This condition should be avoided as the threads tend to run in the grooves. The result is that if there is any unevenness in the thread, or if there is a knot or lumpy place, the yarn generally breaks, producing crooked ends and causing extra work for the weaver. The insertion of new teeth, especially at the sides of the wraith, will stop this trouble.

THE LEASE RODS.—The lease rods are hollow iron rods, pointed at each end. They are fitted into brackets on each side of the headstock. The lease rods are used for the purpose of separating the whole sheet of yarn into as many sheets as there are backbeams.

The constant friction of the yarn on the lease rods wears fine grooves in them. Should these be allowed to get too deep they will cause the yarn to break, on account of the “ends” catching in them when the rods are inserted. These grooves can be removed by glazing the rods on an emery wheel, or by having them turned up in the lathe.

Case-hardened lease rods can now be obtained. These rods, owing to their being so much harder on the surface than the ordinary rods made from wrought-iron piping, reduce the tendency to groove to a minimum.

THE REDUCING OR EQUILIBRIUM VALVE.—This is a valve placed between the cylinder steam feed tap and the cylinder. It is used for the purpose of reducing the pressure of the steam in the feed pipe, and maintaining it at a lower pressure in the cylinders. The pressure can be varied by altering the position of a weight on the valve lever. If this valve be in good working order the pressure in the cylinder can be kept practically constant when the machine is running. A valve which has a tendency to stick instead of working freely may lead the “taper” into trouble, as the pressure in the cylinders will not be uniform. This will give rise to uneven drying of the yarn. In such a case the piston should be taken out of the valve and washed with a strong solution of soap in hot water. By this treatment it is often possible to make a “sticking” valve work satisfactorily.

Some machines have an arrangement fitted to the “setting on” rod for lifting the reducing valve lever when the machine is on the slow motion. By this means the supply of steam to the cylinders is stopped. Without this arrangement steam would be wasted by being forced into the cylinders until the pressure was sufficient to open the safety valve. With this arrangement there is less tendency to scorch the yarn round the cylinders when the machine is being run on the slow motion for a few minutes.

It may be as well to point out, however, that even when the above arrangement is fixed, and in good working order, the cylinders will be hot and full of steam when the machine stops. If the pressure of the steam in the cylinders falls, the heat which is lost has been transferred, to a great extent, to the yarn round them. From this it will be seen that cutting off the steam when the machine stops is only reducing very slightly the tendency of the yarn to become over-dried.

A good "taper," who understands his work, will shut off the steam and reduce the temperature of the cylinders by "running on" a few yards before he stops the machine, and in this way avoid over-drying.

THE PRACTICE OF TAPE SIZING.

The chief mechanical motions of which a tape-sizing machine is composed have been described and it will now be followed by a description of the process itself.

The "tape-sizer" holds the most lucrative position as a workman in the weaving branch of the cotton industry. The responsibilities of the position vary considerably. "Tapers" who run "pure" sized goods bear the least responsibility and have the easiest work. Those engaged on heavy sized goods, shirting dhooties, or

fancy coloured work, require much more skill and experience.

The points of greatest importance in one class of "tapeing" are of minor importance in another. A "taper" who has had experience only with "pure" sizing would probably find himself in difficulties if he were transferred to "heavy" sizing. Similarly, a "taper" whose experience is limited to plain goods has a number of things to learn when placed in charge of a machine running coloured dhootie borders, which have a fair percentage of size on the grey yarn. Men who are accustomed to the latter class of work, and who do it well, have to exercise more care and skill in running one set of beams than is required to run two ordinary "pure" sized "sets."

It would be impossible *to make* a "taper" by giving full and minute details of the work, and therefore much will be left out of this chapter which might otherwise have been included in it. At the same time the authors intend to describe and discuss all points of importance, with a view to imparting more definite and accurate *practical* information on the subject than has yet been published. This information cannot fail to be advantageous, not only to the practical "taper," but also to the manufacturer and the mill manager.

GENERAL DIRECTIONS FOR STARTING THE TAPE FRAME.—Assuming that the "taper" has finished a

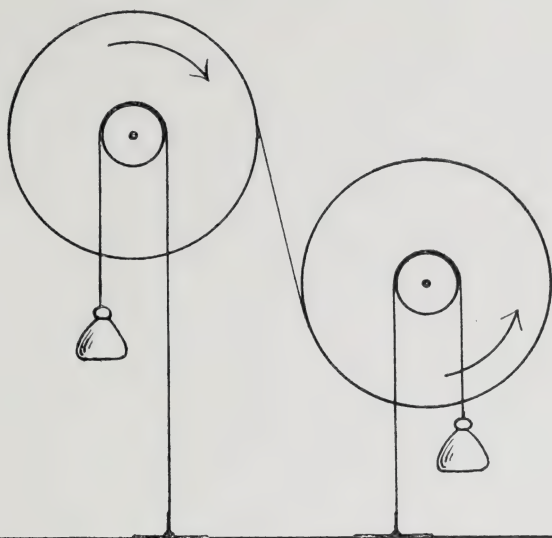
“set” one of his first duties will be to change the wheels, if the next “set” requires to be marked in a different manner. After changing the wheels the required number of backbeams constituting the “set” should be put in; care being taken to put them in to run the right way, and to have each succeeding beam narrower than the one preceding it, provided there is any difference in their width.

Having got the beams in they should be carefully examined to see if they have the right number of “ends,” with the right counts of yarn, and the same length as entered in the book, otherwise the “set” may be started with a wrong backbeam in.

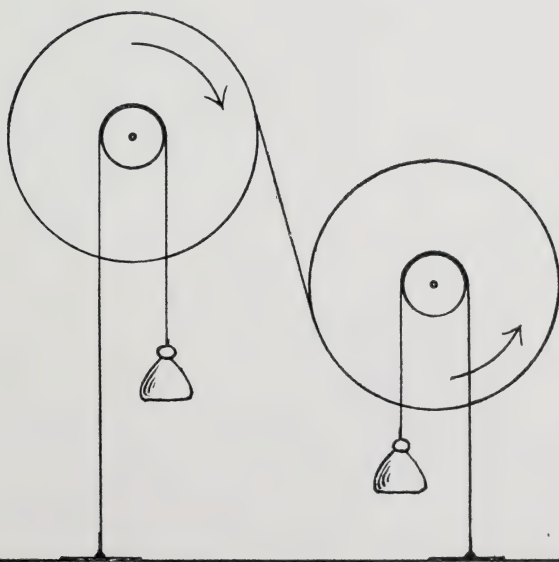
The warper’s number should also be entered in the taper’s book opposite to the respective beams, so as to enable him to put the blame on the right shoulders if there should be any bad work on a backbeam.

After the beams have been examined the weighing straps should be put on the two last beams of the “set.” These straps, which are placed on the boss of the beam flange, are used for the purpose of preventing the backbeams over-running themselves when the machine stops.

There are two methods of putting these leather straps on the beam flanges, *a right way and a wrong way*. An illustration of the right and wrong way is shown in the diagram on page 357.



Right Method of Weighting the Backbeams.



Wrong Method of Weighting the Backbeams.

When the strap is put on the beam flange correctly the friction of the flange against the strap tends to lift the weights up and slacken the strap. When it is put on incorrectly it causes the strap to tighten, and the amount of friction becomes excessive whilst the yarn is unduly stretched. In the correct method of putting on the strap the friction is definite according to the weight, whereas in the incorrect method it is an indefinite and unknown quantity, although the weight is the same in both cases.

When the beams have been adjusted, and the ends in the new "set" tied to the tail end of the old one, the pinion on the driven cone drum shaft is put into gear. The weaver's beam and the friction motion should be also set right. The steam tap leading to the cylinders is then opened. This forces the water which has been condensed in the pipes to the cylinders. The taps leading to the boil pipes are afterwards opened. If these taps were opened before the tap leading to the cylinders the water would be driven into the "sow" box. This would cause the size to be diluted and if the tape frame were situated a long distance from the boiler there might be sufficient condensed water in the pipes to make an appreciable difference in the strength of the size. Such cases are not unknown to the authors. An instance of the effect of condensation came under their notice recently. In

this case the particular firm had only just commenced to tape-size their yarns. The tape room was a one-storied building with an iron roof, and it was situated a good distance from the boiler. They were using an experimental "mixing," containing a large percentage of Epsom salts, in order to put on 100 per cent. of size. The first beam which was run gave about 95 per cent. of size, the second dropped down to 87 per cent., whilst on the third they could get only about 60 per cent. On investigation it was found that an enormous quantity of condensed water was getting into the "mixing." This water came from the pipes, and down the trunk on the tape-frame. The trouble was stopped by fixing a steam trap to the pipes as near to the tape-frame as possible, and by attaching a gully to the rim of the trunk so as to prevent the condensed water running into the "sow" box.

After the size has been boiled, the finishing roller should be put down, and then the tape frame should be run a short distance on the slow motion, in order to allow the sheet of yarn to get straight. The "lease bands" should then be put in. These "bands" are pieces of cotton waste a few inches longer than the width between the backbeam flanges. They are inserted between the ends of each beam in the "set."

After putting in the "bands," the teeth of a comb, known as the "striking comb," are inserted in the

sheet of yarn. The number of teeth in the comb depends upon the number of teeth in the "wraith," and upon the width of weaver's beam it is intended to use. The place where the comb is generally inserted is behind the guide roller which is nearest to the immersion roller. It should be inserted in the sheet of yarn about two yards in advance of the first "lease band."

The teeth of the comb divide the sheet of yarn into a number of narrow strips, with a space between each. If the teeth are equidistant, and the sheet of yarn uniform in density, each strip will contain approximately an equal number of ends.

It is customary to make a mark on the middle strip, with a finger previously smeared with black oil. The position of the middle strip is ascertained by means of a piece of yarn, which is tied round the back of the comb exactly midway between the end teeth.

After pulling the comb out, the machine is run until these strips, or the "striking" as it is generally termed, get to the "wraith." Whilst the "striking" is being run from the back to the front of the machine the "lease" rods are pulled out of their brackets and laid on the floor. The "wraith" is also turned over. This is done to prevent the knots, which have been formed by tying the ends of the old and new sets together, getting broken.

When the "striking" has reached the "wraith," and the sheet of yarn has been straightened, the "wraith" is turned up to its working position. The strip of yarn, with the black oil smear on it, is inserted in the space between the middle tooth and the one next to it. Each consecutive strip is then inserted between the teeth, care being taken not to put two strips in one space, nor to leave a space without one. This operation is termed "laying in."

As it takes a few minutes for the above operations the slow motion is allowed to work intermittently in order to prevent the formation of stiff places through the size baking on the yarn. This would happen if the machine were stopped altogether, owing to the heat of the copper roller.

It is a practice with some "tapers" to keep the cylinder steam tap open whilst "laying in," so as to be able to get running quickly. This practice is not a good one, as the yarn round the cylinders becomes scorched through excessive drying. If chloride of magnesium be an ingredient of the size, this overheating may cause the yarn to become "tendered."

After "laying in" a "lease rod" is inserted between each of the "lease bands" to separate the combined sheet of yarn into as many sheets as there are backbeams in the creel. By this means all the ends are separated from one another. The brackets holding the rods should be adjusted

so as to allow each individual sheet to travel along through the "wraith" apart from any other sheet.

The back "lease rod" is usually much thicker than any of the others and for "heavy" sizing a rod made from two-inch piping is not too large.

After the rods have been got in, the weaver's beam, upon which the "gaiting up" has been wound, is pulled out and a fresh one inserted in its place. The marking motion is then turned to the right place, and the finger of the dial set at figure O. The "wraith" is then adjusted so as to give a sheet of yarn equal in width to the distance between the beam flanges. The press rollers are afterwards lifted up to the beam. Steam is then turned into the cylinders, the size and boil taps are adjusted, and the frame is run at a low speed until the cylinders get hot. During this period the "taper" generally straightens any inequalities in the sheet, by lifting "ends" out of spaces in the "wraith" (which may accidentally contain too many), and dividing them into the adjoining spaces which may contain too few. This is done to obtain a sheet of uniform thickness, by which means the weaver's beam is made the same degree of hardness all the way across.

This straightening up of the sheet should always be performed as near the bottom of a beam as possible, as every end lifted over will come up

crooked in the weaving shed, from the place where it is lifted over, to the bottom of the beam.

Too much care cannot be exercised in getting a good straight bottom, free from broken yarn, for every weaver's beam. If the machine be started at a high speed, and the width of the yarn in the "wraith" is either considerably narrower or broader at one side, or both, than the distance between the beam flanges, "ends" are almost sure to be broken, or a "soft" side formed.

By approximately adjusting the width of the yarn in the "wraith" whilst on the slow motion, and then running slowly for a few yards until it is accurately adjusted, the "taper" can save the weavers endless trouble.

Having described how a "set" is "gaited up," the chief points requiring attention afterwards will be briefly dealt with.

INSERTION OF "DOFFING COMBS."—When the weaver's beam has been filled with yarn a comb should be put in before it is disconnected from the tape frame. This comb is put in to keep the "ends" straight for the "reacher-in" when he is selecting "ends." It is not an uncommon practice for tapers to "doff" a beam without putting a comb into it. The result of this bad practice is to produce "crossed ends" in the weaving shed. Occasionally these "crossed ends" are put down to the size sticking the yarn together and they are described as

“stickers.” It is not a case of the sized yarn sticking together at all but to the cause mentioned. “Crossed ends” can be produced if the teeth of the combs are not kept in good order.

“BROKEN BOTTOMS.”—These consist of a considerable number of “ends” which are broken at the point where they are wound on the weaver’s beam. “Broken bottoms” occur mostly in heavily sized goods, or in “sorts” where the number of “ends” forming the beam are few. The tendency to form “broken bottoms” may be avoided by attention to the following instructions:—

(1) The steam to the cylinders should be shut off about fifty yards previous to getting to the top of a beam.

(2) The tape frame should be run slowly until the yarn, which has been on the cylinders during a stoppage, and thus over-dried, is wound on the weaver’s beam.

(3) The weight on the friction lever should be reduced to the lowest possible working amount, or it should be pulled off altogether, during the time the previously-mentioned dry yarn is winding round the beam. If these instructions are carefully carried out the “taper” will turn out better work, and, at the same time, enhance his reputation as a workman.

OVER-DRIED YARN.—Over-dried yarn may be rectified to a certain extent by treating it with steam.

A steam pipe, in which a number of small holes are bored, is placed in some position between where the yarn leaves the small cylinder and the back "lease rod." This pipe should be fitted with a steam tap, and the holes should face in the direction of the yarn. By opening the steam tap live steam can be impinged on the yarn. This is allowed to continue until that portion of yarn which is over-dried is wound on the beam.

"TAPEING" "LIGHT" SIZED YARN,—“Pure,” or “light” sized goods, must be well dried in the “taping,” especially at the lower portion of the beam, otherwise they will be liable to mildew. At the same time care must be taken to avoid over-drying. “Heavy” sized yarns are not nearly so liable to develop mildew, because they contain sufficient chloride of zinc to prevent this trouble, whereas pure or light sized yarns rarely contain chloride of zinc, or other antiseptic. Mildew is a serious matter in “pure” sized goods unless they are intended for bleaching. In the latter case it does not matter much, unless the mildew has attacked the cotton fibre, or, unless it has produced a “soft beam.”

It requires experience to be able to say when a yarn is sufficiently well dried, without fear of its being under or over-dried. The “feel” of the yarn as it passes between the thumb and fingers is the usual method of judging its dryness. The place

where the test should be applied is between the draw roller and the weaver's beam.

In "pure" sizing it is advisable to have the lower portion of the immersion roller below the surface of the size in the "sow" box, in order to prevent any portion of the yarn being unsized when the machine is on the slow motion.

As previously stated, uniform work of good quality in "pure" sizing demands no great amount of skill from the "taper" if the yarn be sufficiently good in quality and the size be suitable for the "sort" for which it is intended. At the same time the difference between paying attention to many of the details mentioned in the previous portion of this chapter, and being careless, is sufficient to earn a "taper" a good name as a workman or otherwise.

"TAPEING" "MEDIUM" AND "HEAVY" SIZED YARNS.—In "medium" and "heavy" sizing the "taper" is expected not only to produce a yarn which shall weave well, but he has to incorporate a considerable quantity of size with it as well. This weight may vary from 20 or 30 up to 200 per cent. It may be desirable to have a certain "feel" on the cloth also. It is essential, therefore, that the weight and "feel" be kept as uniform as possible. These conditions should be taken into consideration when making the "mixing" otherwise it is practically impossible for the "taper" to obtain them. If they have

been taken into consideration, and a suitable "mixing" made, it is still possible for a careless "taper" to produce beams which, when woven, give a wide range of weights and a great variety of "feels" instead of the desired uniformity.

In order to attain uniformity in sizing it is essential that the following conditions should be observed :—

(1) Each size "mixing" should be uniform in strength and in the percentages of the ingredients of which it is composed.

(2) The ingredients should be treated in the same manner for every "mixing" for the same "sorts."

(3) The size should be fed into the "sow" box uniformly.

(4) The size should be well and evenly boiled.

(5) The speed at which the machine is run should be regulated so as to dry the yarn uniformly.

(6) The "taper" should have sufficient intelligence and experience to enable him to judge, by the "feel" of the yarn, whether these five conditions are being complied with.

(Nos. 1 and 2) It has already been pointed out that it is necessary to have each delivery of the sizing ingredients *of the same strength and quality*. Stress has also been laid on the necessity of making exact measurements and weighings of each ingredient, and also upon the necessity of correctly treating the

size, so that conditions Nos. 1 and 2 have already been discussed.

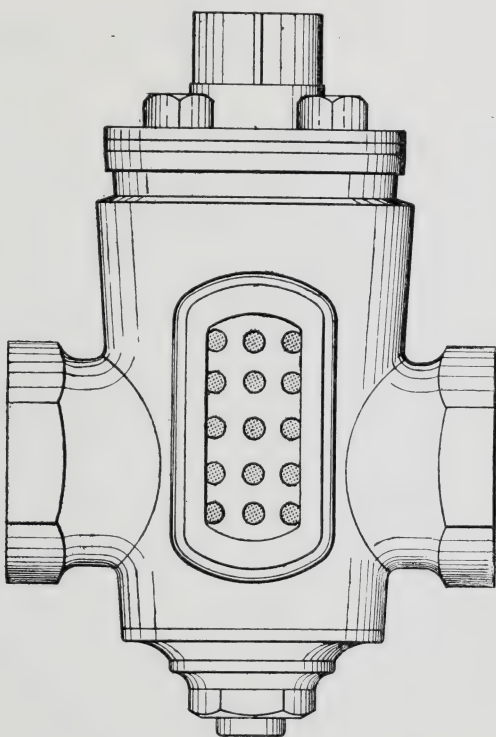
(No. 3) **UNIFORM FEED OF SIZE.**—The uniform feed of the size to the “sow box” depends on the working of the pump, the overflow valve, and the self-feed valve. It will be necessary therefore to describe these appliances and the method of working them in full.

FORCE PUMP FOR PUMPING SIZE.—For “heavy” sizing a three-inch pump with a seven-inch stroke, making fifteen to twenty strokes per minute, will be ample for one machine. Where a variety of sizing is required it is advisable to have a separate pump for each tape frame. This allows each machine if necessary to be on a different kind of size. The pump ought to have regulating screws passing through the valve lids to regulate the lift of the valves. The valve itself is best made in two pieces, the winged or lower portion screwing into the upper part. Old friction flannels, or winders’ listing should be cut up and fixed between the two portions of the valve. This prolongs the life of the valve face and of the seating. The weight of the upper portion of the valve requires to be increased when pumping very heavy size.

An illustration of a size pump, attached to a beck, is shown on page 370.

THE SIEVE TAP.—This is a tap fitted between the size beck and the pump. Its purpose is to

prevent any substance likely to interfere with the working of the valves getting to them. The sieve should be cleaned out at least once a day in order to prevent it getting clogged up. An illustration of a sieve tap is shown below.

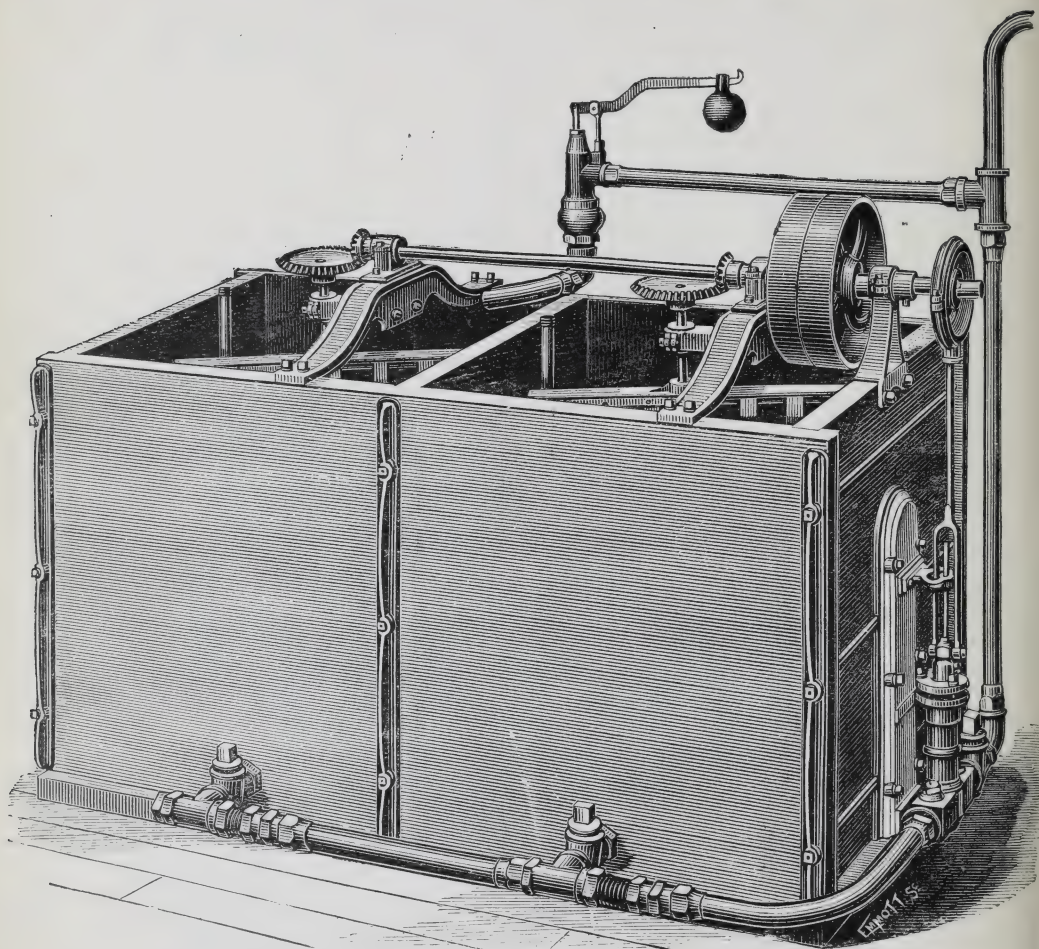


Sieve Tap.

T. Parkinson, Britannia Works, Blackburn.

THE OVER-FLOW VALVE.—This valve, which is shown fitted to a size beck on page 370, is fixed between the pump and the sizing machine. It is used in order to keep sufficient pressure on the size in

the pipes to enable it to reach the "sow" box. When the "sow" box is full, or the self-feed valve nearly

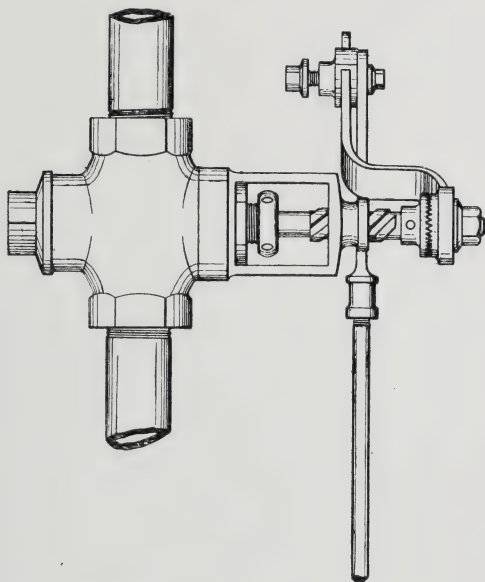


Size Pump and Over-Flow attached to Size Mixing Beck.
T. Parkinson, Britannia Works, Blackburn.

closed, the over-flow valve opens and allows the surplus size to return to the bech from which it was

pumped. The valve should be made in two pieces as recommended for the pump and for the same reason. Care should be taken to keep it in efficient working order and not to over-weight the lever. If the lever be over-weighted it causes unnecessary work to be placed on the pump.

THE SELF-FEED VALVE.—The object of this



Self-Feed Valve.

T. Parkinson, Britannia Works, Blackburn.

valve, an illustration of which is shown above, is to regulate the amount of size entering the “sow” box and to cut off the supply when the “sow” box contains sufficient for working requirements. It is connected to a lever holding the float roller. If the pump and over-flow valve are working right the

self-feed valve will keep a constant amount of size in the box. The rate at which the size is fed to the "sow" box should be kept as uniform as possible. To ensure this the valve and seating must be kept in good working order. The connection between the float roller lever and the valve lever should be firm, and the nut holding the regulating clutch should be screwed tight.

By paying attention to the foregoing details a uniform feed of size to the box will be assured.

(4) UNIFORM BOILING.—In order to boil the size well and uniformly it is usual to have some form of boiling apparatus fixed between the pump and the "sow" box.

The amount of steam required to boil the size varies with different kinds of size, and the rate at which it is being used. In "pure" sizing the amount of size put on the yarn is very small compared with the amount used in "heavy" sizing. In the latter case, therefore, the size remains a much shorter time in the "sow" box before being applied to the yarn and it requires more steam to boil it thoroughly owing to its greater density. On this account it is essential that the size should be boiled, if possible, before entering the box. Not only should it be raised to the boiling point but a certain time should elapse after this point has been reached in order to allow the whole of the size to get thoroughly "cooked." Care should also be taken to have it

boiling in every portion of the "sow" box. It is quite possible to have size boiling in one portion of the box and not in another. This will occur if any of the holes in the "boil pipes" are allowed to get made up, or if the feed pipe does not deliver the size evenly across the box.

A careful examination of the boil pipes should be made periodically to see that the holes are not made up. If any of the holes are made up the size will be imperfectly boiled in their proximity, and uniform boiling will be impossible. The result of passing yarn through portions of size insufficiently boiled is to produce a damper and "stickier" yarn than that which is passing through the well boiled portion of the size. This extra dampness may cause the cloth to stick on the beam, or it may possibly cause the cloth to mildew.

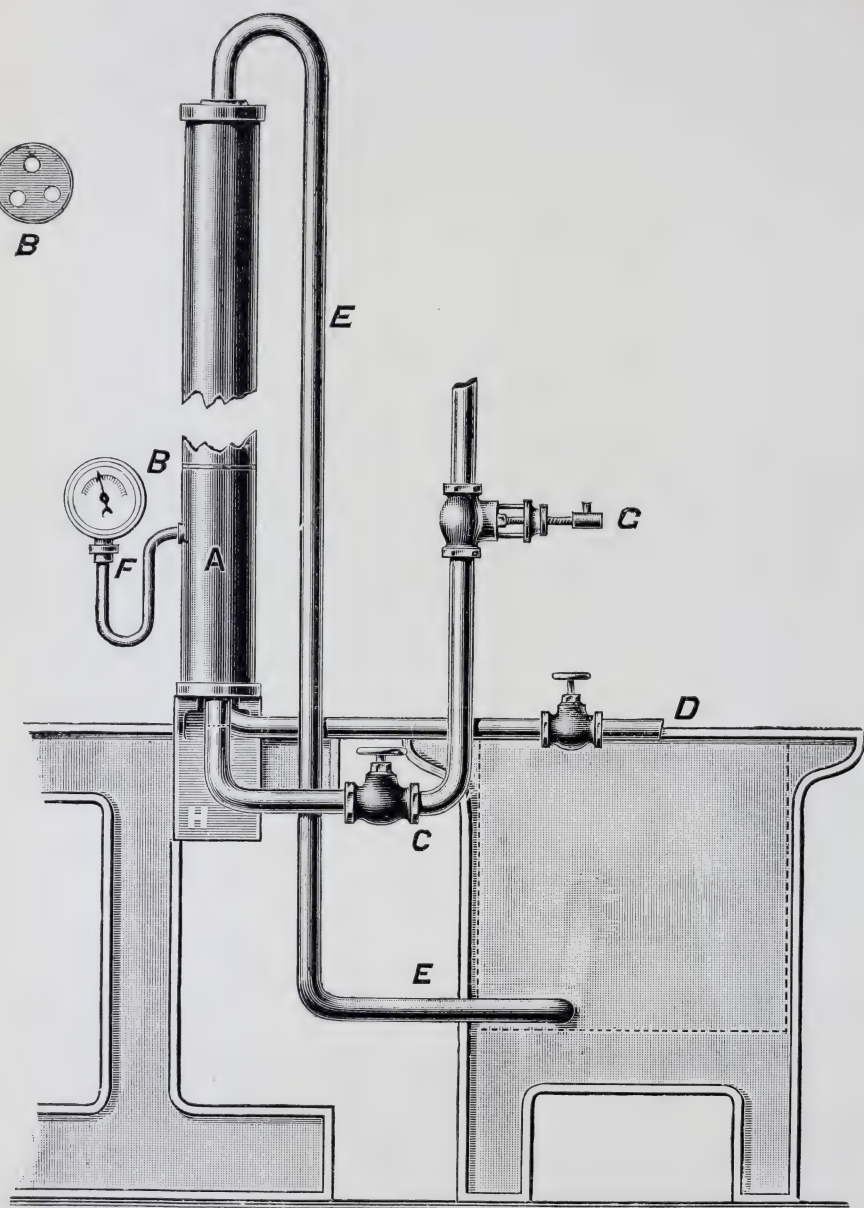
It has already been stated that the object of boiling the size is to burst and break up into fine particles the granules of starch. The temperature at which these granules burst is considerably below the boiling point of the size, *if the whole of the size be at a uniform temperature.* This is not always the case however. If it were every granule of starch would be broken up into particles so small as to render it impossible to determine, by a microscopical examination, what starches had been used in the composition of the size. Yet the authors repeatedly find, when examining size under

the microscope which has been washed from cotton cloth, many unbroken starch granules. These unbroken granules must have been in some portion of the size which has been imperfectly boiled, although the whole of the size may have appeared to boil. Cloth containing a large amount of unbroken starch granules will have a harsh wiry feel and a "bad cover."

SIZE BOILING PAN.—From what has been said as to the importance of thoroughly boiling the size it will be evident that it is necessary to have a good form of boiling pan attached to the tape frame. The authors advise a deep boiling pan, in which the outlet for the size is a few inches higher than the inlet, in preference to a shallow pan. In a deep pan the steam and size have to travel a greater distance before being released through the holes in the feed pipe, and are thus longer in contact.

The capacity of a pan used for "heavy" sizing should be greater than one used for "pure" sizing because a larger reserve of boiled size is needed. This is because the size is used up more quickly in the former case. If a small pan be used the size would get forced into the "sow" box before it was thoroughly boiled. With a large pan the size not only gets thoroughly boiled, but the boiling is effected with the minimum of steam.

Simplicity in construction is the most important feature to consider in boiling pans. Those shown in



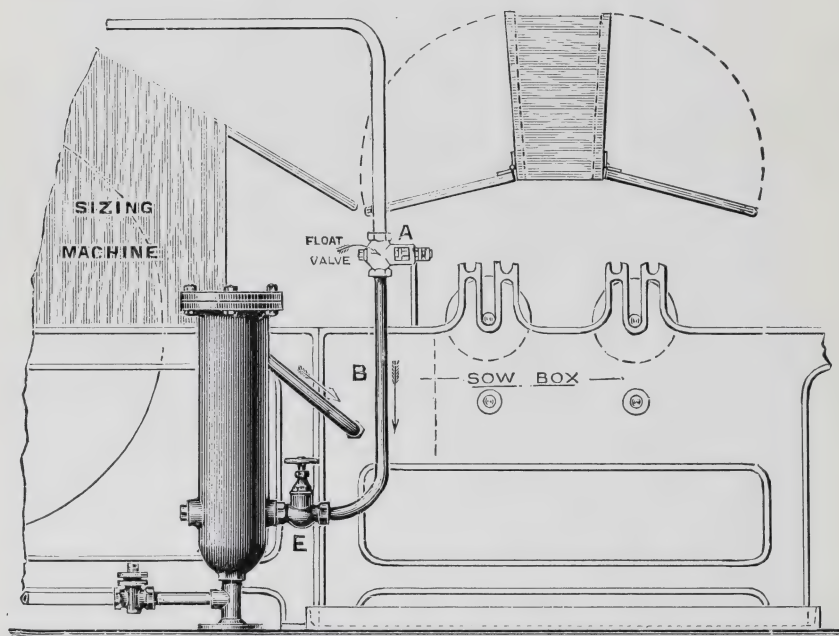
Size Boiling Apparatus.

George Rushton, Britannia Brass Works, Darwen.

the illustrations are amongst the best on the market. They are simple in construction, and they can be made in various sizes. The pan illustrated on *plate xiii*, consists of a seamless copper cylinder A. This cylinder is 5 feet long, and it is fixed vertically to the tape frame by means of the iron angle bracket H in a convenient position near the "sow" box. The size is admitted by the valve C from the self-feed valve G, and steam is connected to the valve D. Immediately the size is admitted into the cylinder A it is operated upon by steam from the pipe D. In this way it is boiled and broken up, and then forced through the holes in mid-feather B, direct into the "sow" box by the copper pipe E.

Another form of boiling pan, attached to a tape frame, is shown in the illustration on page 376. This pan is further illustrated by the diagram on page 377. It is constructed entirely of brass and copper, with brazed joints, and it is tested to 60 pounds pressure per square inch. The following description of the diagram will explain the method of boiling the size in this pan:—The size enters at B or C, as may be desired. It is then drawn through the orifices J.J, by the vacuum caused by the "steam boiling jet" I, and afterwards driven through the mixing nozzle G. It then passes up F, and strikes the deflecting head H, after which it is forced down again and passes the baffle plate K. The size then re-enters at J.J, and again passes the "boiling steam jet" I.

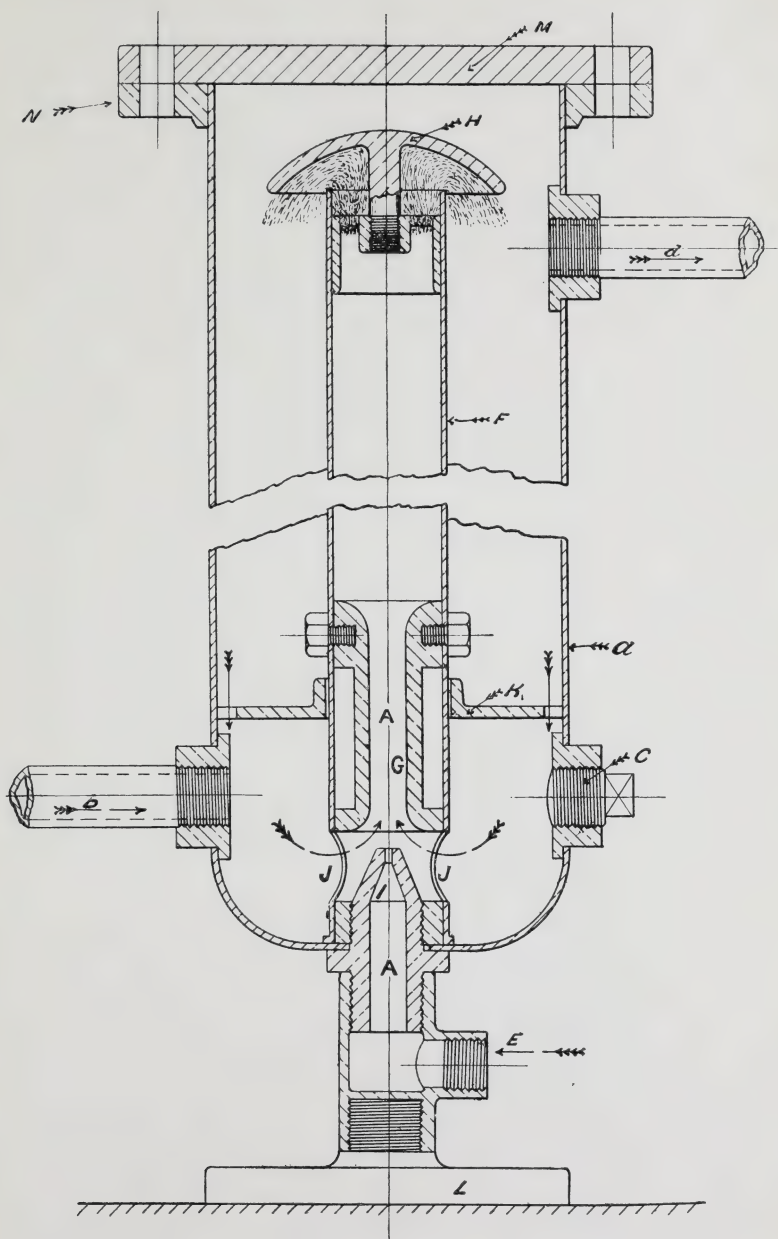
This cycle is repeated again and again when the pan is in use, and in this way the size gets thoroughly boiled. The size should be boiled before the tape frame is started, in order that the ingredients may become thoroughly mixed after standing over night or during the week-end.



Boiling Pan, showing "Self-Feed Valve" (Float Valve).

C. Parkinson, Britannia Works, Blackburn.

(5) **UNIFORM DRYING.**—Uniform drying does not mean that *every* "sort" *should be dried alike*. To dry "heavy" sized yarns as much as "pure" sized would be a great mistake as this would cause too much breakage of the former when the sheet



Size Boiling Apparatus.
T. Parkinson, Britannia Works, Blackburn.

of yarn was separated by the "lease rods." It may be taken as a rule that "pure" sized "sorts" should receive the maximum drying, whilst the amount of moisture left in the yarn may be increased as the percentage of size increases. The dryness or dampness of the yarn depends on too many factors to be stated with any degree of accuracy in a book. At the same time each "sort" is best dried to a degree which experience has shown to be the most suitable for producing good work. Uniform drying means keeping the whole of the beams in any one particular "sort" dried to the standard which experience has proved to be best adapted for it. If the speed at which the machine is running and the pressure of steam in the cylinders be well adjusted one to the other, there ought to be no difficulty in obtaining uniform drying.

It may be advisable to point out that the percentage of moisture in the warp yarn, when converted into cloth, may differ from the amount left in when it leaves the tape room. Yarn well dried but sized with a "mixing" containing a large quantity of chloride of magnesium will absorb moisture in the weaving shed. On the other hand if the yarn be left damp when sized with a "mixing" containing a small quantity of chloride of magnesium, or none at all, it will lose the excess of moisture in the weaving shed and probably become too dry. The amount of moisture left in the sized yarn in the

majority of cloths will be considerably under 15 per cent. Therefore, all substances used as sizing ingredients will lose any excess of moisture over this amount (unless the moisture *natural* to them be over 15 per cent.) before being converted into cloth.

The use of ingredients containing a large percentage of water has already been commented upon, and if *the weight which is retained in the cloth* be taken as a basis, instead of *the weight put in the size mixing*, it will be found that many substances which appear to be cheap are really very dear.

(6) SENSITIVENESS OF TOUCH.—This is one of the most important qualifications of a really first-class taper. It enables him to judge with certainty by feeling the yarn of "sorts" he is accustomed to :—

(a)—If the yarn be under, rightly, or overdried.

(b)—If the size be sufficiently well boiled.

(c)—If any appreciable variation has been made in the size "mixing."

(d)—If the yarn be much under, or over-weighted.

Every taper "feels" the yarn as it passes from the draw roller to the weaver's beam, but it requires sensitive finger ends and a receptive brain to be able to transmit this information from his fingers to his brain. This sensitiveness can be acquired only by practical experience and by careful attention to the various "feels" peculiar to sized yarn. The yarn

should be felt with the idea of deriving some information, and not merely from habit, as is too often the case.

LIGHT WEIGHTS ON "FIRST BEAMS."—The first weaver's beam run at the beginning of a day's work is more liable to be light than any succeeding one. This is due to several causes. In the first place it is customary to wash the size off the copper roller after the machine is stopped. The water used for this purpose dilutes the size in the "sow" box, and consequently it will give a lower percentage of size on the first beam which goes through. The size is still further diluted by the condensation of the steam used for heating the contents of the "sow" box. To counteract this the amount of size left in the box should be reduced to as small a working quantity as possible when running the last beam of a day's work. If this be done a larger amount of fresh size can be pumped into the "sow" box when commencing work the following day. It is possible also to avoid the use of water for washing the copper roller if the machine be run for about two yards on the slow motion after the boil taps are shut, and the dirty portion of the copper roller be left at the under side when "turning back,"

The tape frame should be run at the highest possible speed for the first beam until the full weight of size is assured. *The faster the machine*

is run the greater will be the amount of size put on the yarn.

SOFT BEAMS.—Not only are light weights likely to occur on the first beam, but there is always a possibility of having a "soft beam" when using "pure" size. This is especially so where farina is used. As previously stated this starch is liable to lose its adhesiveness by prolonged boiling. But no matter what ingredients are used the extra amount of condensation which takes place through heating the old size in the "sow" box tends to dilute the size. The dilution may be sufficient to reduce its adhesiveness to such an extent as to make a "soft beam," unless care be taken to counteract it. The procedure usually adopted is to mix two or three pounds of sago or farina in a small quantity of water, and add this to the contents of the "sow" box when first "boiling up." Care must be exercised that none of this mixture is allowed to get upon the yarn, or upon the rollers, as it might cause the threads of yarn to adhere to such an extent as to make it impossible to separate them when the yarn reaches the lease rods.

TO OBTAIN A GOOD "FINISH" ON THE YARN.—In order to obtain a good "finish" on the yarn several conditions must be complied with. In the first place the size must be well boiled. In the second place the copper roller must be sufficiently strong to run true when heated. In the third place

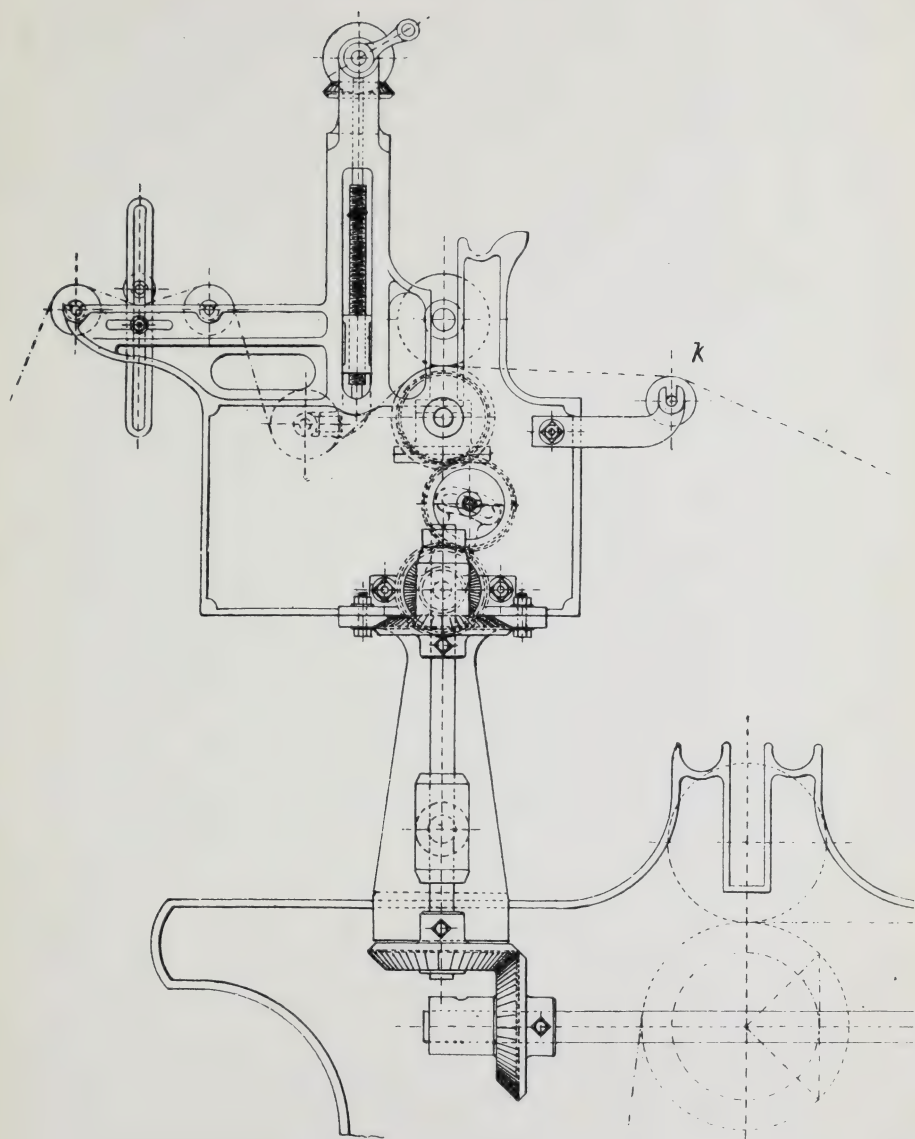
the finishing roller must be of sufficient weight to press the size well into the spaces between the individual fibres of which a thread is composed, and the flannels and fent on this roller should be free from cuts or "scrimps."

The weight of the finishing roller depends to a certain extent on the class of work for which it is to be used. For ordinary work a weight of six or seven pounds per inch of width is ample, but for "heavy" sizing a roller weighing eight pounds per inch would be better. If a heavy roller be employed it will be necessary to make the "size" rather stronger in order to obtain the desired weight than it would be if a lighter roller were used. This matter has already been discussed on page 296.

"COLOURED" TAPEING.

For coloured work it is usual to have an extra "sow" box, commonly termed the "coloured" box. An illustration of one is shown on page 383. It is simply a "sow" box in miniature, and is used only when the grey and coloured yarns are not sized alike. If the grey yarn has to be heavily sized whilst the coloured yarn has to be sized sufficiently to make it weave only, then the extra "sow" box will be necessary.

The "coloured" box should be fixed either over the small cylinder, or in front of the "sow" box. If



Arrangement of "Coloured" Sow Box.
Wm. Dickinson & Sons, Blackburn.

fixed over the small cylinder it is not very convenient for the "taper" when running coloured "sorts," but it is more out of the way when running plain "sorts" only. In this position the coloured yarn is not so subject to "twirling" as it is if the box be fixed in front of the "sow" box, but there is more liability to damage if the size boils over.

When the "coloured" box is fixed on the front of the "sow" box the immersion rollers in both "sow" boxes can be arranged to wind up or down simultaneously.

The copper roller in the "coloured" box derives its motion from the side-shaft by means of an upright shaft driven with bevel wheels. Another pair of bevel wheels and a pair of spur wheels on the top of the upright shaft complete the driving mechanism. The spur wheels can be used as "change wheels" for altering the speed of the copper roller. These change wheels would be better if they contained more teeth than they are made with at present. This would allow *slight* alterations to be made in the speed. These alterations are essential in order to keep the coloured yarn at the right tension at each side of the box. If the yarn be slack between the backbeam and the box, and an alteration of one tooth is made in a driving change wheel which has seventy teeth, the copper roller will afterwards run seventy-one yards in the same time in which it previously ran seventy. This may be too much,

and the yarn will tighten at the side which was previously slack, and be much too slack at the other side. An arrangement which would allow of a change of one yard in two to three hundred yards would be preferable.

The above difficulty is always experienced with backbeams having grey yarn in the middle and coloured yarn at the sides. If particular attention be paid to the number of empty dents allowed in the warping mill the grey and coloured yarns can be arranged to unwind off the backbeam at the right speeds.

In the sizing of coloured bordered dhooties, where a fair amount of size on the grey yarn is required, the grey yarn should be taped, if possible, so as to leave it *damper* than the coloured yarn. This is essential for several reasons. In the first place heavily sized grey yarn requires more moisture than pure sized yarn in order to enable it to weave well. In the second place, unless the coloured yarn is well dried, there is a danger of mildew developing. This is a frequent cause of damage in coloured bordered dhooties because the size for the coloured yarns does not, as a rule, contain preservative substances. The mildew may not show on the coloured yarn in every case, but it frequently “marks off” on the grey yarn after it has been packed. This matter is discussed in detail in the chapter on mildew.

If the ordinary way of threading the yarn round the cylinders be employed, it is practically impossible to leave more moisture in the grey yarn than in the coloured yarn, as the latter goes over the big cylinder on the top of the grey yarn. Under such conditions the grey yarn is always *drier* than the coloured.

There are two methods by which this defect may be remedied. The first, which has already been mentioned on page 329, consists in arranging for the coloured yarn to run next to the surface of the drying cylinders. This arrangement, which is shown in the diagram on page 387, is brought about as follows :—

A number of guide rollers are fixed in such a manner that the coloured yarn travels from the copper roller for a short distance down the front of the big cylinder. It is then turned back by passing over and under a guide roller. This transfers the coloured yarn from the upper surface to the lower surface of the grey “sheet” of yarn, and thus brings it in direct contact with the surface of the big cylinder.

After being turned back at this point the yarn is brought round the big cylinder in the opposite direction to that usually taken until it gets well round to the front of the cylinder. Here another guide roller is fixed and the yarn goes round it after leaving the cylinder. Other guide rollers are arranged to convey the yarn to the small

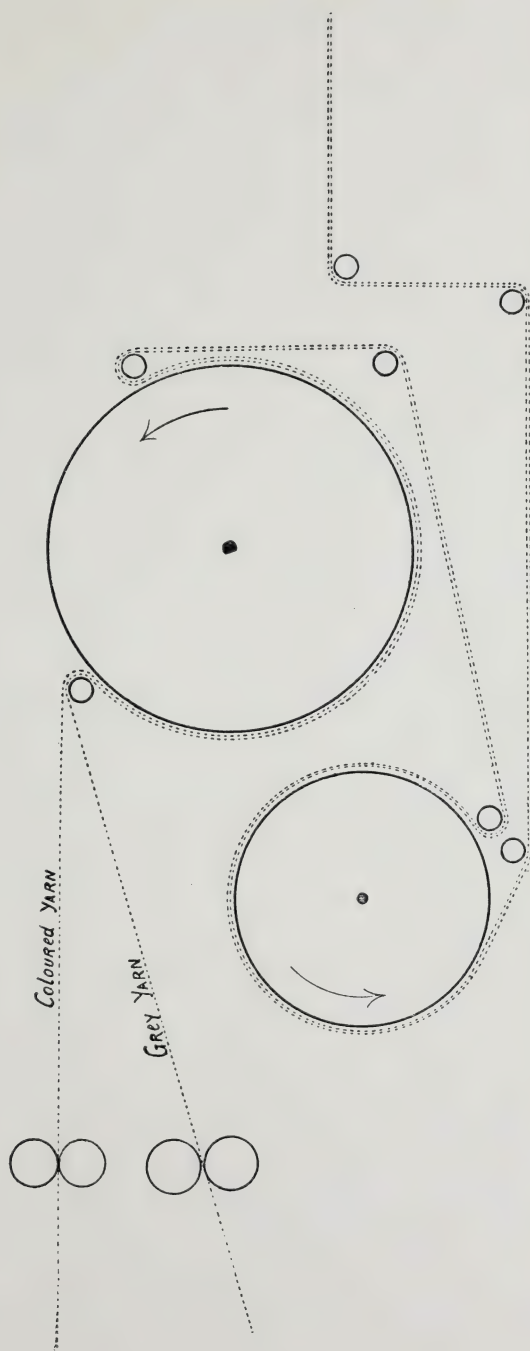


Diagram showing Guide Rollers arranged for running the Coloured Yarn next to the surface of the Drying Cylinders.

cylinder, which is threaded in the usual way. From the small cylinder it passes to the headstock.

The second method adopted for properly drying the coloured yarn is to use an extra drying cylinder. This cylinder is usually about eighteen inches in diameter, and it is driven positively in the same manner as the mechanism of the "coloured" box. This is done in order to prevent any extra tension being put on the coloured yarns. This extra cylinder may be fixed either over the small cylinder or over the headstock. In the former case two guide rollers are arranged so as to give the coloured yarn as much lap round the "coloured" cylinder as possible. The coloured yarn is thus partially dried before it passes round the ordinary drying cylinders. When the "coloured" cylinder is placed over the headstock, the coloured yarn receives an extra drying after leaving the ordinary cylinders.

The pressure of steam in the ordinary cylinders and in the "coloured" cylinder can be varied. Therefore if the pressures in the cylinders and the speed of the machine are regulated the grey yarn can be wound on the weaver's beam damp, whilst the coloured is dry. For all shirting dhooties this is a decided advantage.

The position occupied by the coloured back-beam in the creel varies. Where only one coloured beam is required, it may occupy the first, second or third place. If the second place be used, a roller is

fixed under it to support the yarn between the third and the first beams. The authors prefer the second place as the “taper” is better able to control the rate at which the coloured beam “runs.”

One of the things to be guarded against in coloured work is the “twirling” of the coloured yarn. This takes place between the “coloured” box and the drying cylinder when the frame is stopped or when it is on the slow motion. The sized ends twirl round one another when wet, and when they are dried it is almost impossible to separate them without breaking. This twirling is usually caused by the coloured yarn being slack, or unsupported, for too great a distance. The use of thick size for the coloured yarn has also a tendency to cause it.

To prevent “twirling,” rollers are usually employed to bring the coloured and grey “sheets” together as soon as possible after the coloured yarn has left the “sow” box. The “coloured sheet” must be kept tight, and the mixing used for sizing it should be composed of such ingredients as will give a very thin “mixing,” and yet be strong enough to make the yarn weave well.

When the combined sheets of grey and coloured yarn reach the headstock the coloured yarn is separated from the grey yarn by means of a roller, which is fixed a few inches higher than the measuring roller. If the whole of the coloured yarn be intended for the borders, it is taken to each side of the wraith,

the teeth of which are made about half-an-inch longer, as previously described on page 351.

Two wires are arranged parallel with, and in front of the wraith, and just behind the sheeting rollers. These wires are used for the purpose of supporting and steadying the pins which are employed for separating the coloured stripes from each other, thus keeping them in their places on the weaver's beam.

It would probably serve no useful purpose to go into every detail in connection with "coloured" or plain "tapeing." Sufficient has already been written to enable those who never have had any practical experience in running a machine, but who are in positions requiring a knowledge of "tapeing," to obtain an insight into the most important details of the tape frame, and the process of tape-sizing.

CHAPTER IX.

Ball, or Warp Sizing.

*The Tinting of Yarns in the Process
of Sizing.*

Warp Bleaching.

BALL OR WARP SIZING.

THE operation known as ball or warp sizing is confined almost entirely to three classes of yarns, viz :—

1st.—Yarns for fancy coloured goods.

2nd.—White yarns.

3rd.—Grey yarns of low counts where a large amount of size has to be incorporated with the yarn, and where a certain “feel” and appearance is required.

Ball sizing is a process particularly adapted for sizing coloured yarns as will be explained later, but for ordinary grey yarns, and for grey yarns of fine counts, it cannot compete with tape sizing. In ball sizing three separate processess are involved, viz. :—Sizing, Drying, and Beaming, whereas in tape

sizing the whole of these processes are performed in one operation.

There are instances, however, where certain markets require heavily sized grey cloth which must possess a peculiar "leathery" feel and appearance. This "feel" and appearance is characteristic of ball sized yarns, and it cannot be imitated on the tape frame. So long, therefore, as there is a demand for such cloth there will be a demand for ball sized grey warps.

Ball sizing produces a round and very pliable yarn, and it is also claimed by ball sizers that they can produce a yarn which will look and "feel" several counts heavier than if tape sized. There is a considerable amount of truth in this statement inasmuch as the threads are not flattened as they are when tape sized. The ingredients used in the size are somewhat different to those employed in tape sizing and this has a considerable effect on the results. For one thing it is customary to use soluble mineral substances, such as Epsom salts, to a greater extent than it is in tape sizing. Chloride of zinc is also employed to a greater extent as a weighting ingredient, whereas in tape sizing it is usually employed as an antiseptic for the prevention of mildew only. Soluble substances of this description tend to swell the yarn.

Apart altogether from the ingredients, the difference in the nature of the operations affects the

character of the yarn. In tape sizing the yarn is run through the size, then through the nip of the copper and finishing roller and immediately dried in the form of a flat sheet on the drying cylinders. From the cylinders it passes to the weaver's beam on which it is wound. The whole of these operations naturally tend to flatten out the threads.

In ball sizing every operation tends to preserve the roundness of the threads and render them pliable. The yarn is passed through the size in the form of a rope instead of in the form of a flat sheet. It is afterwards dried on the drying cylinders. The latter operation is a distinct and separate process, and it is not usually carried out immediately after the yarns have been sized. The object aimed at in drying is to leave a certain amount of moisture in the middle of the warp. As the warps are not beamed for some considerable time after sizing and drying the moisture has a chance of becoming evenly distributed throughout the mass of threads. This has the effect of giving to each individual thread a mellow pliable condition.

From the difference in the operations it will be at once apparent that, although tape sizing has many advantages over ball sizing as far as speed and economy are concerned, there are yet many purposes where the latter process can be successfully carried on which can never be superseded by tape sizing. The sizing of coloured yarns for fancy coloured woven

goods is a case in point. It would be quite impossible to successfully size such yarns on the tape frame. There are many reasons for this. In the first place it is necessary to run each colour separately on account of the "bleeding" of the different colours. In the second place coloured sizing is made up more of a succession of small lots which could not possibly be treated in an economical manner on the tape frame. It is rarely the case that such lengths of yarn are run as for standard grey cloths or bleaching cloths. In the third place warps containing very few "ends" can be successfully treated in ball sizing because the yarn may be doubled as often as necessary to get a warp of the right thickness. Thus, instead of the warp being passed through the size at its full length it can be treated in its reduced length. Doubling the warp makes no difference to the results or to the after process of beaming.

There are certain firms who have a regular trade for striped warps in standard colours. Such firms will dye and size warps containing 2,000 to 3,000 "ends" of each of these colours for stock. When they receive an order for any design they split them up into as many "ends" as may be required to make the design. Thus a weaver's beam may require, say, 1,000 "ends" of white yarn, and 100 to 200 "ends" each of various coloured yarns, such as red, pink, green, heliotrope, brown, etc., and these would be taken from stock.

A firm having a trade of this kind would avoid the trouble of dyeing and sizing small lots of warps. Not only would the shades be more exact for repeat orders, but the yarn would be in better condition for weaving after being stored for some little time.

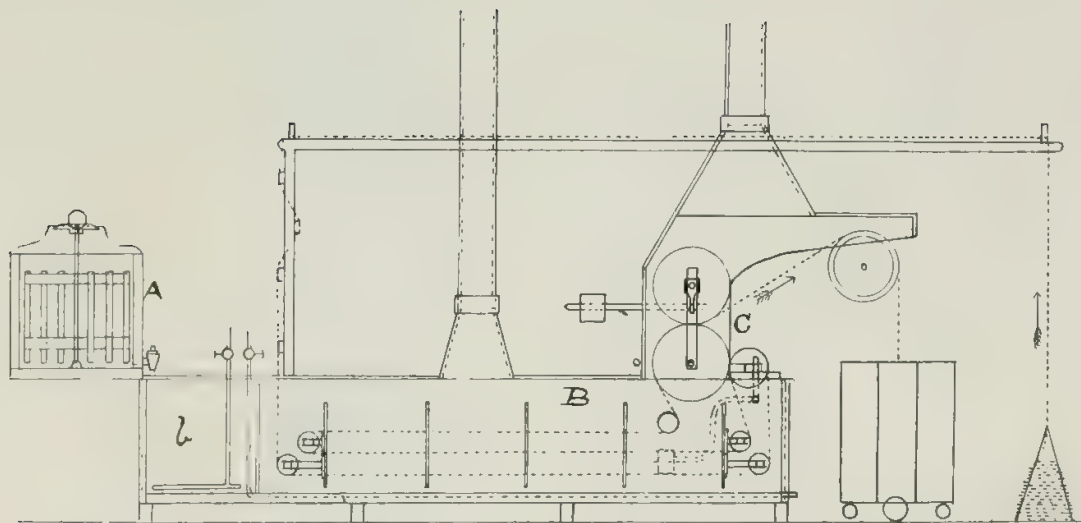
From what has been said it will be seen that, although some firms can arrange to deal with large warps, it is not always possible to do this, and to try and treat small lots of warps on the tape frame, apart from the question of the "bleeding" of the colours, would be economically impossible.

As a rule the manufacturer who uses ball sized warps does not size them himself, but buys them from the dyer. As a general thing this is an advantageous arrangement for the manufacturer, as he is not only saved the trouble of sizing but also the trouble of dyeing, and to carry out the operations properly he would require to be a practical dyer as well as a sizer and manufacturer. It will be readily understood that if the manufacturer purchased "*unsized*" coloured yarns to match those in a piece of cloth, he would be liable to alter the shade when they were sized. The dyer always takes this into consideration, and arranges that the yarns shall be dyed so as to come up the right shade when sized. The manufacturer is thus relieved of most of the responsibility as far as shade of colour is concerned.

Although it is an advantage in many ways to leave the sizing in the hands of the public dyer

there are also disadvantages. In the first place the manufacturer has to use such yarn as may be supplied to him by the dyer, and if he is desirous of getting brighter shades he has to depend upon other people. A manufacturer may require not only an improvement in his colours and his sizing, but he may want to develop a speciality business. In such circumstances as these he will not want other people to know what he is doing, and it will be better that he should dye and size his own yarn. This may entail the putting down of a bleaching plant as well as a plant for dyeing and sizing. There is no doubt that this matter will have to be carefully considered by English manufacturers of coloured goods. Most of the competition in the cotton trade in this country is in this class of cloth, and until recently Continental firms were beating the English manufacturer out of the field because they were putting a better dyed cloth on the market. The colours were brighter and clearer than anything we were getting. The result of this competition has been that several manufacturers have recently equipped their works with bleaching, dyeing, and sizing machinery, and they are now turning out better work than their competitors from the Continent. This is a matter which all makers of specialities in coloured goods should consider very seriously, as they are only certain of getting exactly what they want





A—Boiling Box B—Sizing Machine b—Boiling Compartment C Squeezing Rollers

Model arrangement of Ball or Warp Sizing Plant, showing method of Immersing the Yarn for Heavy Sizing

by having the control of the whole of the processes in their own hands.

BALL SIZING PLANT.

The apparatus used in 'ball sizing' differs considerably from that used in tape sizing, but the method of mixing the sizing ingredients together is practically the same in both cases.

A model arrangement of a ball sizing plant, of which the following are the essential parts, is shown on *plate xiv.* :—

The Mixing Becks.

The Boiling Pan or Beck (used for boiling the size for heavily sized grey yarns).

The Clay Pan.

The Sizing Machine, with its various appliances.

The Drying Machine.

MIXING BECKS.—Several becks are required for mixing the sizing ingredients together, the number depending upon the variety of the sizing undertaken. At least two becks are required for storing a standard mixture of flour and water. A third beck may be required for mixing the various ingredients together, although very often the "mixing" is made in the size box without using a mixing beck at all. Each beck should be fitted with agitators, similar to those described on page 271.

The becks for the flour, and the mixing beck should be arranged on different levels, so that the flour in steep may be run into the mixing beck below. The mixing beck should be on a higher level than the sizing machine, so that the completed "mixing" may be run into the size box. Unless this arrangement be carried out it would be necessary to employ pumps, or ejectors, to raise the flour and the size to the necessary levels.

BOILING PAN OR BECK.—A boiling pan or beck is necessary for heavily sized grey yarns where China clay is an ingredient of the "mixing." It has been previously mentioned that it is necessary to boil China clay for two or three hours, in order to break it up into fine particles. Where the "mixing" is a small one this pan may be used for mixing the ingredients together, and boiling them previous to their use in the size box.

THE SIZING MACHINE.

The sizing machine, an illustration of which is shown on page 399, consists of the following essential parts:—

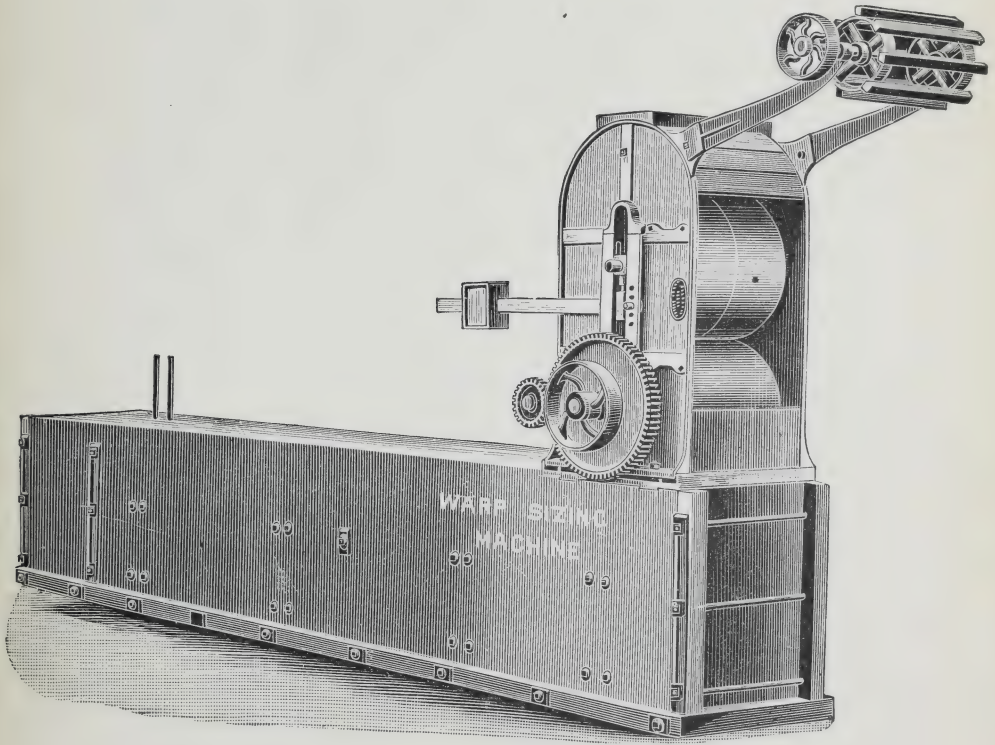
The Size Box, with its various appliances.

The Squeezing Apparatus.

The Delivery Winch.

SIZE BOX.—The size box is constructed generally of wood, but sometimes entirely of iron. Occasionally

it is made of brass, and finished off on the outside with planished steel plates, packed with non-conducting material. It is fitted with a number of copper brackets, in which are a number of eyelets.



Warp Sizing Machine.

Corresponding to each eyelet is a copper roller. Both the eyelets and the rollers are placed below the level of the size.

The size box is fitted with 1-inch copper pipes, through which steam is passed for the purpose of

boiling the size. These pipes are perforated with one row of holes, which should face upwards so as to avoid "blowing" the warp as it travels through the box. The pipes are usually arranged in three rows at the bottom of the box. The steam to the two side pipes is controlled by one valve, whilst the middle pipe is controlled by a separate one. This allows the sizer to use more or less steam as required. When running it is customary to use the two side pipes only, whilst the middle one is used when boiling the size previous to the warp being run through. This arrangement is carried out to avoid the danger of the steam from the middle pipe blowing on to the warp.

In the larger size boxes, the size is first boiled in a separate compartment before it comes in contact with the warp. The boiled size passes into the main compartment under the dividing partition, which is fixed so as to allow a space between the bottom of the partition and the box.

The size box is made in various lengths, according to whether it be intended to be used for one class of yarn continuously, or for small lots of coloured work. For coloured work it may range from five feet in length upwards, whilst for heavy grey sizing it is usually constructed from eighteen feet to twenty-two feet long.

In heavy grey sizing a large size box is always used, and in order to obtain the necessary weight of size on the yarn, the warp is arranged to traverse the box in the manner shown on *plate xiv*.

The length of the size box, and the number of times the warp traverses it, together with the rate at which the machine is run, determines the length of time the yarn is immersed in the size. In some cases the warp is arranged to traverse the box twice or three times. It may be taken as a general rule that the longer the warp is immersed in the size the better will be the result.

It is not always convenient to give coloured yarns a very long immersion, because each colour of yarn has to be sized separately, and very often fresh size has to be made for each "sort," especially if they are light shades. A small sizing machine is, on this account, more economical than a large one for small lots of "coloured" work.

At the same time it should be understood that it is not necessary to waste any size even when dealing with small lots of various coloured warps. It is entirely a question of management. Where it is possible it should be arranged for certain colours to follow each other through the size box. For instance, if light pinks are sized first they may be followed by dark pinks, reds, and maroons. The same arrangement can be carried out with other colours; light blues followed by dark blues;

light greens followed by dark greens ; cream shades by buffs, yellows, gold, orange, brown, etc.

If it be inconvenient to run the shades as here-with described, the size from one lot of warps should not be thrown away, but should be run into a well or reserve tank. This size may be used for any very dark colours or for blacks. As a matter of fact, if the size has been properly made from suitable ingredients it will be in better condition after it has been agitated by the passage of the warps, and pressed by the nip of the squeezing rollers, and after it has been well boiled, than it was when freshly prepared. Fresh size is "raw," and does not give the same "mellowness" to the warps as that which has been well worked and boiled. Not only is this the case, but old size does not require as much tallow as new size to produce the same pliability in the yarn. Experience has proved that size improves as the boiling is continued, and the dark coloured warps which have followed in the same size as the light shades are better in every way. It is important that the old size should be "strengthened up" with a little new size occasionally on account of the dilution which takes place in the box through condensation from the steam used for boiling purposes. The longer the boiling is continued and the more condensation (and consequent dilution) will take place. For this reason it is better to have as

small a volume of size as possible in the box when first starting.

In ball sizing it is not customary to have an automatic flow of size to the machine. The addition of fresh size from the mixing beck is made through a pipe fitted with a plug tap. It will readily be seen that this arrangement is sufficient on account of the capacity of the box, which may hold anything from two or three hundred to a thousand gallons.

SQUEEZING APPARATUS.

The squeezing apparatus, which consists of two heavy rollers fitted with levers and weights, is used for squeezing the superfluous size from the yarn as it leaves the size box.

THE TOP ROLLER.—The top roller, which is acted upon by levers and weights, is generally made of sycamore. This roller should be about 24 inches in diameter when new (according to the size of the machine), and it should be lapped with a linsey lapping. The best form of lapping has a linen warp and a woollen weft. The lapping is about 40 to 50 yards long when new. As the outside lap gets worn it is cut off so as to present a fresh surface to the warp.

In covering the roller the end of the flannel is first tacked on, after which it is wound as tightly as possible, and fastened to the roller by means of

long nails which are driven through the sides of the roll of flannel into the wood.

At the present time iron rollers are being used in the place of sycamore. These rollers are fitted with wooden plugs in order to allow the "lapping" to be fixed with nails.

The top roller rests on the bottom roller and works in a slot. It is not driven direct but derives its motion from the bottom roller.

THE BOTTOM ROLLER.—The bottom roller is made of cast iron, fixed upon a wrought iron or a steel shaft. It is usually about 24 inches in diameter and about 20 to 22 inches long. This roller runs in brackets and it is either driven by means of spur wheels or direct from the shafting. The bottom roller is usually run without lapping of any description.

The pressure on the squeezing rollers is regulated by the levers and weights, which are placed at each end of the top roller.

The correct regulation of the pressure on the squeezing rollers is a matter of the greatest importance in ball sizing. The amount of pressure to be used depends upon the class of yarn undergoing treatment; but it may be taken as a general rule *that the warps should not be left too wet*. In this condition they would turn up too boardy, and in many cases they would be found matted together after drying on the cylinders.

To ascertain whether the yarns are correctly sized and sufficiently squeezed the sizer twists the warp between his fingers and thumbs. This test enables him to form a correct judgment as to the condition of the warp. If it has been sufficiently dried by the squeezing rollers he should be able to "feel" the size but not able to squeeze more than a small quantity of it from the warp. The "feel" of the warp will enable him to judge whether the size is sufficiently "mellow." If the size sticks to his fingers like glue it shows that there is not sufficient tallow in the "mixing." This method of testing may appear to be rough and ready and somewhat of the nature of "rule of thumb," but when applied by an expert sizer it is sufficient to enable him to determine the condition of the warp.

Much better results can be obtained by using a strong size, and squeezing the warps well, than by using a weaker size, and leaving the warps "wet." Coarse counts of yarn may be left with more size and moisture in them than the finer counts. The latter should be well squeezed in every case.

The foregoing remarks apply mainly to those yarns which are "pure" sized. In heavier *coloured* sizing the warps are generally treated twice. In the first operation the warp is run through a "mixing" composed of flour and water only. It is then well dried, and afterwards run through a "mixing" consisting of flour and water, together

with the necessary weighting, softening, and anti-septic substances, such as Epsom salts, tallow, chloride of magnesium, and chloride of zinc. This matter is further dealt with on pages 414 and 415.

In heavy grey sizing the warps may be treated sufficiently in one operation to obtain the desired weight, if the system of immersion, as shown on *plate xiv*, be adopted. In this case the warp is passed through the size box once, and afterwards pressed in the squeezing apparatus. It then re-enters the size box, through which it is passed twice. By this arrangement a heavy weight of size combined with a good firm "feel" can be obtained by once sizing.

DELIVERY WINCH.—This winch, which is shown on page 399, is used for the purpose of taking the warp from the squeezing rollers and leading it into the box or truck waiting to receive it. The winch is driven a little faster than the warp is delivered from the squeezing rollers, and in this way a fair amount of "pull" is exerted.

THE DRYING MACHINE.—The drying machine consists of a number of cylinders arranged either vertically, as shown on page 408, or horizontally. These cylinders are made of tinned iron or of copper, and they are provided with suitable buckets for discharging the condensed water. Each cylinder is fitted with vacuum valves.

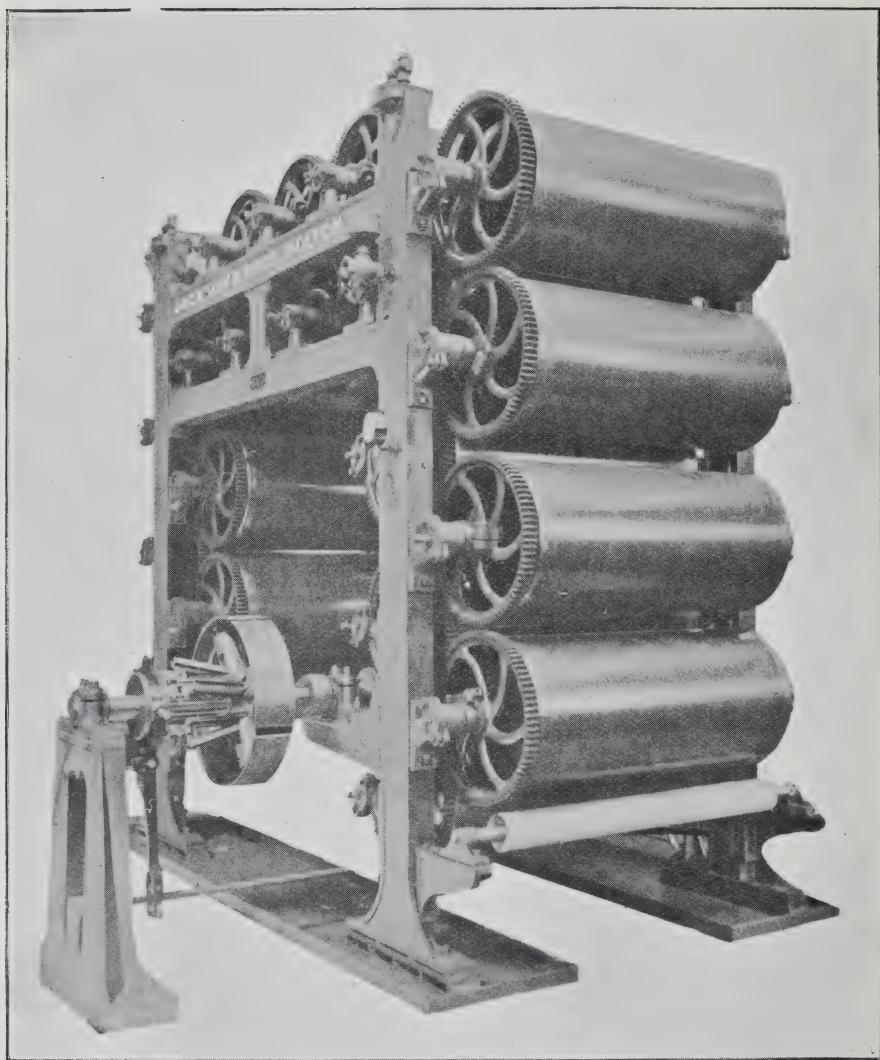
The vertical arrangement of the cylinders is the

more convenient of the two for many reasons. In the first place the cylinders can be more easily inspected when required, In the second place the warps can be more readily got at in case of breakages. In the third place the cylinders can be readily detached for repairs, and altogether it is a more convenient arrangement in every way.

Many firms, however, prefer the horizontal, or group arrangement, as they claim that better work can be performed with it, and the warps can be kept "mellower." They also claim that there is less danger of forming "slack yarn."

It is probable that in most cases the horizontal arrangement has been selected simply because the particular building is better adapted for it. Cylinders arranged vertically require a lofty room, and this is not always convenient. As far as the question of "mellowness" is concerned this is a matter for the sizer to arrange by suitable treatment of the warps.

In drying, the warps are passed round the cylinders the required number of times, or "laps," and for this purpose a guiding "raddle" is provided. Two or four warps may be dried at the same time on one machine. After drying, the warps are delivered in coils into sheets. These sheets should be laid on a low wooden platform which has been covered with linoleum or a good oilcloth. The smooth surface thus presented removes any danger



Vertical Drying Machine.
Messrs. Jackson & Brother, Wharf Foundry, Bolton.

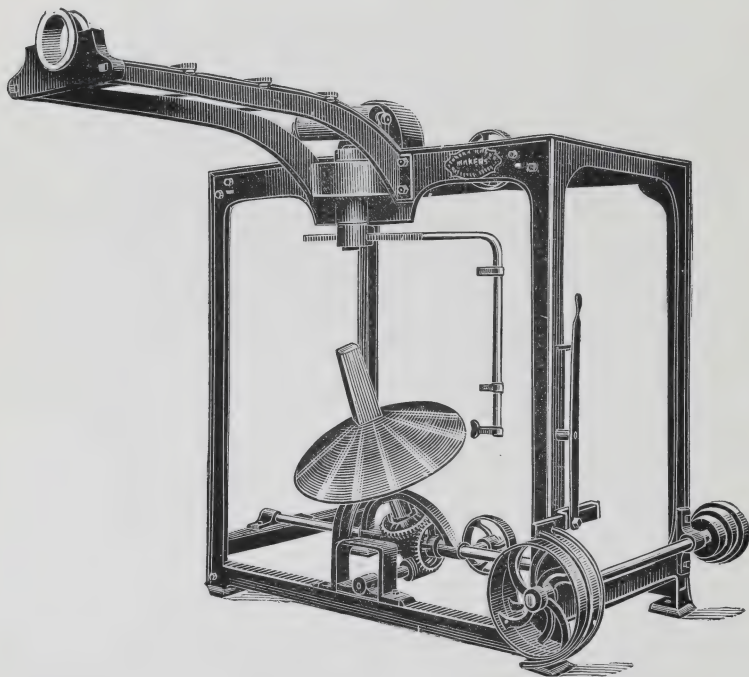
of damage to the warps or to the sheets through coming in contact with splinters from the surface of the platform.

The drying machine may be driven either by a friction arrangement or by a small engine, as shown on page 408, or by means of an electric motor, so that the speed of the machine may be regulated to suit the class of work being done. The machine shown in the illustration is driven by an expanding pulley on the same shaft as a spur pinion, which engages into a wheel on the drying cylinder. The object of this expanding pulley is to adjust the speed of the drying machine to that of any other machine with which it works in conjunction. The advantage of this arrangement is more applicable to piece goods than to warps, as the speed of the drying machine should be governed by altering the speed of the engine itself.

If an engine be used for driving the machine the exhaust steam should be blown into the drying cylinders. The engine should be constructed with two cylinders so that it can be started from any position. If it contains only one cylinder the fly-wheel will require "baring" over into position each time the engine is started.

BALLING MACHINE.—In addition to the apparatus already described, a "balling" machine is sometimes used. This machine, an illustration of which is shown on page 410, is used for wrapping the sized and

dried warp into a ball, in which form it is much more convenient to handle and pack for delivery to the customer. The balling machine is used chiefly for "light" sized yarns. It has a tendency to "break" the size a little, so that it is advisable not to use it for heavily sized yarns. The latter should be allowed



Balling Machine.

to remain in "sheets," as they "mellow" better in this state than if they were made into a ball.

THE SIZING INGREDIENTS.

The ingredients used in ball sizing are very similar to those used in tape sizing, excepting that

Epsom salts are used to a greater extent. It is usual to keep a standard mixture of flour and water. This may contain three pounds of flour in each gallon of the mixture for coloured work and light grey sizing, whilst for "heavy" sizing the proportions will be similar to those given on page 277. The flour should be allowed to steep or ferment for at least a week, in order to separate the granules of starch. Where it is intended to size grey yarns only the flour may be "steeped" with chloride of zinc, as previously described on page 82 *et seq.* Chloride of zinc, however, is not always a permissible ingredient, and where its use would be objectionable it will be necessary to ferment the flour in order to get the desired smoothness.

It has been previously stated that fermented flour contains acids. This would be objectionable when sizing yarns dyed with colours sensitive to acids, such as benzo reds, etc. In such cases it would be necessary to neutralise the acids with soda crystals, commonly known as washing soda. This substance is better than caustic soda for this purpose, as a slight excess would not be injurious to such colours, whereas a little free caustic alkali might be injurious.

Coloured yarns and white yarns are sized either for weaving purposes only or for weight. In "pure" sizing the mixture should consist of flour, or some other form of starch, tallow, or some other

fatty or waxy softener, and water. If the goods have to be weighted, Epsom salts should be used for this purpose, along with the chlorides of magnesium and zinc. China clay is not a suitable substance to employ for weighting coloured yarns, as it would affect the colours and give the yarns a "peppery" appearance unless suitably tinted. This is due to China clay being an insoluble substance.

After a suitable "mixing" has been made in the beck for the class of yarn about to be sized it is run into the size box, where it is boiled for one to one-and-a-half hours. This amount of boiling is necessary, otherwise the yarn will stick together after sizing and drying, and would be difficult to open out, in the after process of beaming, without damage.

"MIXING" FOR COLOURED YARNS.

A typical "mixing" to put 35 per cent. of size on coloured yarn, together with the directions for applying it, will give the reader a clearer idea of the methods adopted in *coloured* ball sizing. For coloured work this weight is usually obtained by passing through the machine twice.

First Passage.—A "mixing" containing $1\frac{1}{2}$ pounds of flour to each gallon of water is first made and boiled for 1 to $1\frac{1}{2}$ hours. The warps are run through this and afterwards thoroughly dried on the drying cylinders.

Second Passage.—To every 150 gallons of the mixture of flour and water the following ingredients should be added:—

Epsom Salts	...	...	...	...	1 cwt.
Tallow...	...	...	...	...	20 pounds.
Chloride of Zinc at 102° T.	...	...	...	...	15 gallons.

The warps are passed through this second "mixing," and afterwards dried. This time it is necessary to avoid over-drying, and the warps should come off the drying cylinders rather damp. They are afterwards allowed to lie over-night in sheets, in order that the moisture may be evenly absorbed by the yarn, and thus give to them the desired "mellow" and pliable condition.

"LIGHT MIXING" FOR WHITE YARNS.

The following "mixing" is suitable for white yarns which require to be sized for weaving only.

Farina	...	...	...	...	56 pounds.
Paraffin Wax	...	...	...	...	2 to 6 pounds.
Tallow	...	...	...	...	1 to 2 pounds.
Water, sufficient to make when boiled	...	...	...	...	100 gallons.

N.B.—Where a firm feel is required, rice or maize starch should be used in place of farina, and the mixing well boiled. Farina will not stand too much boiling.

Half the required quantity of water should first be placed in the size box. The farina should then be mixed by hand in a suitable vessel with another portion of cold water. This is best performed by

mixing about 10 pounds at a time, and as soon as it is thoroughly mixed it should be poured into the size box, the operation being continued until the whole of the farina has been incorporated. The paraffin wax and tallow is then added, and the mixture brought to the boil. The boiling should be continued for $\frac{1}{2}$ to 1 hour.

The quantity of paraffin wax and tallow for the foregoing "mixing" depends upon the class of yarns undergoing treatment. For the finer counts, such as 40's and upwards it will be advisable to use the maximum quantity given in the recipe, whilst for counts such as 26's to 30's, the minimum quantity may be used.

N.B.—Counts below 20's will require a stronger "mixing" than the one given for weaving only.

It will be as well to mention at this point that flour is not suitable for sizing white yarns on account of its creamy tint.

It is not necessary to go into details in regard to the ingredients, and the various "mixings" used in heavy grey sizing; nor is it necessary to further describe the method of applying the size to the yarn. Sufficient has been said to give the practical reader all the information he may require. It is worthy of mention, however, that in very heavy ball sized grey yarns it is customary to use a far greater proportion of chloride of zinc and a less proportion of chloride of magnesium

than is used in tape sizing. In some cases it is customary to use a larger proportion of tallow also. The writer, in the course of his practice as a consulting chemist, has come across "mixings" in which chloride of magnesium has been present in very small quantities, whilst the proportion of tallow has been nearly double the amount used for the same percentage of size in tape sizing. The object of this is to give to the yarns a great amount of pliability, and to give to the cloth a peculiar dry "leathery feel" when woven and pressed.

There is a demand in certain markets for a cloth which will almost stand on end when opened out, and this condition is obtained by using very little chloride of magnesium as a "softener." In order to give the yarns the necessary moisture for good weaving it is customary to place wet fents on the weavers' beams.

When the cloth is afterwards folded and pressed it causes the laps to stick slightly together when opened out, and each lap will almost stand upright. It is probably due to this custom of wetting the yarn on the weaver's beam that such an excess of chloride of zinc has come to be used in heavy ball sized warps. The authors are aware that it is customary in some cases to damp tape sized yarns in a manner similar to that described, but it is rarely done to the same extent as for ball sized yarns. If tape sized yarns were damped to the same extent,

mildew would develop in the weaving shed. This is because chloride of zinc is rarely used in the mixing in the same quantities as it is in ball sizing.

THE TINTING OF THE WARPS IN THE PROCESS OF BALL SIZING.

The tinting of yarn has already been dealt with under tape sizing, but in this process it can be carried out to a limited extent only.

Ball or warp sizing lends itself to tinting to a very much greater extent, and in recent years a considerable development has taken place. The reason why the process cannot be adapted successfully in tape sizing will be apparent to those who have read the description of tape sizing and ball sizing. It has been shown that tape sizing can only be successfully applied to very long lengths of yarn, whereas much smaller lengths of yarn can be treated economically in ball sizing.

The process of tinting is not applicable to hank sizing for a different reason. Tinting must be carried out in boiling size to be at all successful. In hank sizing this would be impossible.

Tinting is carried out with various objects. In the first place it is necessary to "blue" bleached yarns in order to produce a brighter and a better white. In the second place a fairly good white may be obtained by blueing unbleached yarns made from good clean American cotton. This is known as an

"imitation bleached yarn." In the third place tinting is carried out with the object of dyeing the yarn some distinctive colour such as various shades of pink, blue, green, heliotrope, imitation indigoe, imitation linen shades, etc., through the medium of the size. These operations are being carried out with a great measure of success for certain classes of cotton goods where cheapness in production is an essential condition.

"BLUEING" BLEACHED WARPS.

Bleached warps may be "blued" in a size tinted with any shade of blue desired. The dyes most frequently used are methyl violet, methylene blue, victoria blue, benzo sky blue, and diamine sky blue.

Bleached warps should be sized with a "clear boiling" starch like farina. Wheaten flour is not suitable as it deadens the white. A good farina should be used for this purpose as low grade farinas have a tendency to form "soft beams" in the weaving shed.

Bleached two-fold yarns are not usually sized and the operation of "blueing" is best carried out in the soap bath.

"IMITATION" BLEACHED YARNS.

At the present time there is a considerable demand for yarns for cheap goods which will look white when woven with coloured yarns. These

yarns have taken the place of "half-bleached" yarns. They answer the purpose equally well for certain goods and they can be produced much more cheaply.

So long as these "imitation" bleached yarns are not compared with bleached yarns they look fairly white and they suit the coloured stripes and checks for which they are intended.

For the production of "imitation whites" a good clean yarn made from good class American cotton should be employed.

In order to produce a bleached effect on grey yarns a blue of a reddish tint should be used. The red neutralises the yellow tint natural to American cotton, whereas a "bluey" blue would have a tendency to produce a greenish effect.

In order to get the best results it is necessary to size and tint twice. The double boiling and "blueing" reduces the original colour of the yarn much more than if it were boiled once only. In the first passage only half the depth of tone should be aimed at. Thus, if a "lot" of twenty warps are being treated they should be run through the tinted size once, then reversed and run through a second time. The second run gives a splendid touch to the tone and the result is altogether superior to that which is obtained if the full tint is produced in one passage. The warp should not be "dried up" between the first and second run unless a "double" size is required. In all cases it is better

to run a trial lot in order to get the right tint before dealing with the whole of the warps.

TINTING CREAMS.

Various shades of cream may be obtained in the sizing operation. Occasionally the tints are produced on yarn which has been bleached or "half bleached," but in many cases they are obtained on natural grey cotton. Bleached yarn gives a much superior effect, but for certain fabrics the former is quite good enough. The principal colours employed in producing creams are chloramine yellow, chrysamine yellow, chrysophenene yellow, benzo-chrome brown G, and mikado orange.

Where a straw or corn shade is required it will be necessary to use the brown or orange dyes along with the yellows, according to the tint required.

TINTING PINKS, ROSE SHADES, ETC.

A great variety of pink shades can be obtained in the sizing operation. Either bleached or "half bleached" yarn, or natural grey yarn may be used as required. The most useful dyes for this purpose are erica pink, the diamine colours, benzo fast red, various shades of geranine pink, rhodamine, rhoduline, magenta, etc. The results are better and more even if a second run be given as described under "imitation" bleached yarns.

TINTING SKY BLUES, ETC.

Many light blue shades can be obtained by tinting the size. Darker shades may be obtained by passing the warp a second time through the size, which should be kept at the full boil. Light shades of blue can be got by one passage, but if evenness of colour be required it is better to use a weaker dye and run twice. If darker shades are required it will be necessary to run twice, using a much stronger solution of dye. In this way almost any depth of colour may be obtained. If the warps require to be "twice" sized they must be "dried up" after the first passage. This is not necessary if "once" sizing be sufficient.

"TOPPING" INDIGOS.

It is a common practice to "top" indigo dyed warps where the yarn is required for very cheap classes of cloth. The "topping" is performed in the sizing operation as follows:—

The warps are first dyed a light indigo, after which they are run through a size tinted with methylene blue, bismarck brown, and magenta. The brown and magenta dyes give body to the methylene blue, and, at the same time, impart the red tint natural to indigo. If very dark shades are required it will be necessary to use a certain proportion of black dye. Some surprising results

can be obtained in "topping" indigo dyed yarn if suitable colours be used in the size.

TINTING HELIOTROPES.

Many shades of heliotrope can be obtained by tinting the size. Various shades of violet, blue, and magenta are used for this purpose. The principal dyes which may be employed are diamine violet N, oxydiamine violet R, direct blues, and various shades of magenta. Direct heliotropes are now being manufactured and employed in tinting to a considerable extent.

TINTING SAGE GREENS.

Many shades of sage green can be obtained in the size box. For this purpose mixtures of yellow, orange, and blue dyes should be used. From these colours almost any shade of sage green can be obtained.

There are also many new direct green and sage green dyes on the market at the present time, and with them a great variety of work can be carried out in the size box which formerly could only be done by dyeing.

TINTING LINEN SHADES ON COTTON.

There is a considerable business done in cotton yarns tinted to imitate linen yarns. They are employed in the manufacture of certain cloths such

as imitation linen dress goods, etc. The object is to obtain the shade of unbleached linen. Linen shades may be obtained by the use of mixtures of various shades of brown with direct black. The black dye is used to deaden the effect of the brown. The principal brown dyes employed for this class of tinting are cotton brown A, cotton brown N, diamine brown 3G, catechine brown 3G, pluto brown, benzo-chrome brown G, benzo brown G, diamine nitrazol brown BD, diamine nitrazol brown RD, direct brown GG. The particular shade of brown depends upon whether a yellowish or reddish tint be required.

WARP BLEACHING.

Warp bleaching and dyeing are essential parts of the warp sizers business. Warp dyeing is beyond the scope of a work devoted to sizing but the bleaching of warps may be dealt with.

For *pure whites* it is necessary to subject the warps to a full bleach, and they should be kier boiled. This process is also essential for certain very delicate shades of dyed yarn where special brightness and bloom are required in self-coloured plain goods, in which the weft and warp have to be the same shade of colour. Most light shades, however, may be successfully dyed on "machine bleached" or on "half bleached" yarns, and medium shades may be

dyed on yarn which has been "scoured" only, *i.e.*, ash boiled and "soured" on the machine. As a general rule it is unnecessary to kier boil for dyeing purposes except for special requirements, such as previously mentioned, where perfect evenness of shade has to be obtained. "Machine boiling" and bleaching is quite sufficient for most classes of dyed yarns and also for certain "whites" which are required for stripes and checks. At the same time it is necessary to point out that it is only possible to soften and remove the objectionable ticks and motes found in cotton yarn by kier boiling, and where they would be objectionable kier boiling must be resorted to.

Kier boiling is necessary for *pure whites* and for very delicate shades of dyes for other reasons. In the first place, unless the yarn be thoroughly "bottomed" there is always a tendency for the natural colour of the cotton to strike through the dye and spoil the tint. This is also the case where *pure whites* are required. It is a common thing to find white cloth discoloured after it has been stored for some time if the yarn has not been sufficiently boiled. It will be advisable, therefore, to deal with warp bleaching in two sections, viz.:—"kier boiling" and "machine boiling."

THE KIER BOILING PROCESS.

In this process the warps are first passed into a three-box "wetting out" or boiling machine, where

they are boiled with soda ash in the first two boxes and washed in the third. From the "wetting out" machine they are carried by means of a winch into the first kier, which may be either a high pressure kier or an open kier according to the bleaching, or to the convenience of the bleacher. Each class of kier has its advantages and disadvantages and these will be discussed later. The warps should be plaited in long even layers by boys standing in the kier. These boys should be shod with clogs without iron soles and the soles should be attached to the uppers with copper nails. If iron comes in contact with the warp it will become iron-stained and this is a very serious matter when dealing with warp bleaching.

The warps should be boiled with soda ash and caustic soda for eight hours in the pressure kier, using 1 per cent. of dry soda ash and 1 per cent. of caustic soda solution at 70° Tw. to the weight of cotton treated. If the open kier be used the boiling should be continued for 12 hours, using the same proportions of soda ash and caustic soda.

After boiling, the warps are led into a four-box washing machine which is arranged as follows:—The first box is used for washing, the second for "souring" with acid, at 1 to $1\frac{1}{2}^{\circ}$ Tw., and the third and fourth for washing. From this machine the warps are led into the second kier and again boiled with soda ash and caustic soda, using half the quantity of

soda ash and caustic soda employed in the first operation. This time the boiling should not exceed four hours in the pressure kier and six hours in the open kier.

After the second boiling the warps are led back to the machine where they are again washed in water. From here they are led to the chemic cisterns where they are plaited down by boys. The chemic liquor is then pumped up from a well or reserve tank underneath the cistern and sprayed over the yarn. This operation is continued for four hours. The chemic liquor should be used at about $\frac{1}{2}$ to 1° Tw. After chemicking, the warps are led back to the four-box washing machine where they are washed in the first box, "soured" in the second, and washed in the third and fourth. From this machine they are led to another four box machine where they are run through water in the first box, boiling soap and water in the second and third, and water in the fourth, after which they are carried to the drying machine. If the warps are for "twice" sizing they may be given the first passage through the size in the condition they come from the nip of the washing and soaping machine, but if they have to be "once" sized only they will require to be dried first. Two-fold yarns intended for "whites" may be "blued" in the soaping process as previously mentioned.

Such briefly are the operations involved in kier boiling. Certain important details not mentioned in this description may now be dealt with more fully.

Where the warps are boiled under pressure great care must be taken that they are thoroughly "wet out" before they enter the kier otherwise damage is almost certain to occur during the boiling process.

The object of "wetting out" is to discharge all traces of air in the cotton. Unless this precaution be taken the oxygen will, in the presence of caustic alkalies at high temperatures, act on the cellulose, and form oxycellulose, and the yarns will be tendered wherever this occurs.

If the warps are boiled in an open kier there is less danger of damage from the production of oxycellulose, but the process takes longer and the motes and ticks are not so easily softened and removed.

Care must also be exercised that all the air is driven out of the kier before it is finally closed down, and, in order to effect this, the "air cock" should be left open at the commencement of the boiling until it is judged that the air has been entirely driven out with the escaping steam. The "air cock" should be left slightly open during the whole of the boiling process. No danger need be feared in pressure kier boiling if the process is carried out properly, and if the right type of kier be employed.

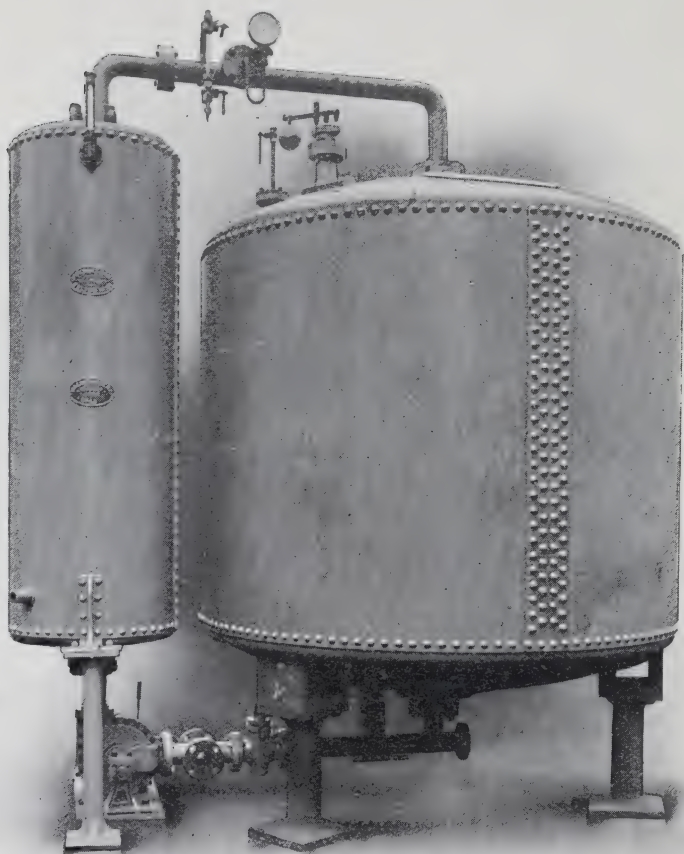
The best form of high pressure kier for boiling warps is shown on page 428. This kier has come into high favour since the introduction of the caustic soda process of bleaching. It is fitted with a heater and centrifugal pump as shown in the illustration. Many advantages can be claimed for it over the old type of high pressure kier. In the first place, no live steam enters the kier, and therefore no dirt can be carried over from the boiler to stain the warps. In the second place, the liquor used for boiling is not diluted by the steam and so remains constant as far as strength is concerned. In the third place, perfect circulation is maintained, and lastly, less steam is required to maintain the temperature in the kier.

The following description of the method of working the kier will more fully explain its construction:—

After the kier has been charged with the warps to be treated, the liquor, which consists of a solution of soda ash and caustic soda previously mixed in a cistern arranged for this purpose, is admitted at the connection at the bottom of the kier, where it passes through the underside of the grid. This is accomplished by first opening the liquor valve and the air cock and closing the circulating valves and the outlet valves.

By feeding the liquor from the bottom of the kier upwards the warps are prevented from being compressed or packed, and this allows the liquor to

circulate freely through every portion of the yarn thus ensuring even treatment. Another advantage



Walsh Type of High Pressure Kier, showing Tubular Heater,
Pump and Circulating Pipes, etc.

Messrs. Jackson & Brother, Wharf Foundry, Bolton.

obtained by forcing the liquor upwards is that the air is more easily driven out of the kier.

When the kier has been charged with sufficient liquor, as indicated by the gauge, to cover the warps to a depth of about 12 inches, the supply is shut off by closing the valves. The liquor is circulated through the heater by means of a centrifugal pump.

A simple form of indicator shows how the liquor is circulating.

After the warps have been sufficiently boiled the pressure in the kier is let down by shutting off the steam from the heater. Clean water, preferably hot, is forced through the heater into the kier, in order to wash out as much of the alkali as possible.

All types of kiers should be thoroughly lime-washed previous to use, and this lime-washing should be repeated every few weeks, or whenever required. Care must be exercised by the bleacher that no part of the kier is left unprotected, otherwise iron stains are sure to occur. These stains are very objectionable in warp bleaching, as they have a tendency to tender the yarn, and they are not so easily removed as in piece goods.

MACHINE BOILING AND BLEACHING.

As previously stated, it is not always necessary to subject the warps to kier boiling and for many purposes the boiling and bleaching can be carried out in a perfectly satisfactory manner on the machine. The writer does not recommend machine bleaching

for warps which have to be *pure white* or for those which have to be dyed the most delicate shades for plain self-coloured goods for the reasons already given on page 423. Good results, however, may be obtained in the production of "whites" for stripes and fancy designs, and in the production of "bleached bottoms" intended for dyeing many pale shades, such as pinks, creams, blues, heliotropes, canary tints, etc. As a matter of fact many of these colours are dyed on warps which have been "scoured" only, but there is no comparison with the results obtained on bleached yarn. Bleached yarn gives a brightness and clearness of tint altogether different from that which is produced on unbleached cotton.

One disadvantage of this process is that the ticks and motes are not softened or removed to anything like the extent as they are in kier boiling.

In machine boiling and bleaching the warps are led into the boiling machine which should be constructed with at least four boxes. In the first three boxes they are boiled with soda ash and caustic soda, and washed with water in the fourth. Two to four pounds of soda ash and the same quantity of caustic soda, at 70° T, should be added to the water in each box, and the liquor should be "strengthened up" as the work proceeds. This is left to the judgment of the bleacher who can tell by experience, and by the

appearance of the yarn, when the addition of fresh soda ash and caustic soda is required.

After the warps have passed through the first machine, as herewith described, they are led to a second four-box machine, each box of which is charged with "chemic" or bleaching liquor. The warps are passed through this liquor and afterwards led into boxes where they are allowed to "air" for some time. They are then run through a six or eight box machine where they are treated as follows:—In the first and second boxes they are washed, in the third "soured" in acid, in the fourth and fifth washed, and in the sixth soaped. If the warps do not require soaping the last box should be used for washing.

Before leaving this portion of the subject it may be as well to mention that it is customary in many places to run the warps through *warm* "chemic," and it is also customary to use the acid "sour" warm. Whether this is advisable is a matter on which there are many different opinions. There is certainly a danger of producing tendered warps unless the "chemic" be used with a great deal of care and discretion. At the same time it must be admitted that the process is carried on regularly without complaints of damage occurring. It must be taken into consideration that the passage of the warps through the bleaching liquor is rapid, and that they soon cool down. The object of

using warm acid for "souring" is to remove more quickly the stains which may occur through insufficient boiling and washing.

"BOILING" AND WASHING MACHINES.

The boiling and washing machines are usually constructed of pitch-pine. They are driven by means of a shaft arranged along the back of the machines. This shaft should be "set" perfectly level. The driving gear is arranged with a counter-shaft and fast and loose pulleys. The speed of the pulleys should be from 150 to 200 revolutions per minute. The best arrangement for driving is by means of a pinion and a spur wheel.

The machines may contain four or more boxes, according to the work to be carried out. Each box is usually 30 inches wide, 30 inches deep and 66 inches long. They are fitted with a pair of squeezing rollers, immersion rollers, "throw-out" gear, boil pipes, "let-off" pipe, and delivery winch.

SQUEEZING ROLLERS.—These rollers are placed over the partitions of the boxes level and square with the driving shaft.

The bottom roller, which is driven, should be from 11 to 12 inches in diameter and care should be taken that all the bottom rollers on the machine are of the same diameter, otherwise they may damage the yarn by causing too much drag on it. These rollers should be very carefully wrapped with a

“hessian lapping” and any *slight* increase in the diameter of successive rollers on any one machine (which may be required for the purpose of exerting a slight pull), should be got by slightly increasing the “lapping.” It is only possible to get the exact amount of “lapping” for each roller of the machine for correct working by a practical test under working conditions.

The top roller should be 10 to 11 inches in diameter, and it should be “lapped” with two or three rounds of “hessian.”

The squeezing rollers should run at 33 revolutions per minute and the speed of the machine should then give 2,000 yards per hour.

IMMERSION ROLLERS.—These rollers may be made either of copper, brass, iron or wood, according to the purpose for which the machine is employed. Usually there are four top and five bottom rollers in each box. They must be “set” perfectly level, and also parallel with the squeezing rollers, otherwise the warps will not run true. This will be quickly discovered when the machine is set to work. The rollers should be fitted to turn easily whilst hot. A “sticking” roller is a common cause of damage to the warps, and it is not unusual to find the rollers working “tight” in new machines. This is due to the makers not allowing for the expansion which takes place when they are heated. The rollers may run easily enough whilst cold,

but they stick as soon as the temperature is raised.

Iron rollers may be employed for boiling with soda ash and caustic soda, and for ordinary washing purposes. For "chemic" it is better to use wooden rollers, whilst for the acid used in "souring," brass, copper, or wooden rollers may be used.

"THROW-OUT GEAR."—The machine should be fitted with a "throw-out" gear running the full length of the front of the machine. A "dog leg" crank is connected with the "throw-out" rod and each box should be fitted with "throw-out" handles. Those who have to work the machines will appreciate the advantages of this arrangement. If the "throw-out" gear is arranged with a fast counter-shaft a smaller belt will be required and the machine throws out quicker.

THE BOIL PIPES.—The boil pipes are perforated, and they may be made either of copper or iron, according to requirements. Iron pipes may be used for soda ash and caustic soda boiling.

"OVERFLOW" OR "LET-OFF" PIPES.—"Overflow" pipes should be fitted on the inside of the boxes where possible, and arranged just clear of the top roller. These pipes should be fitted with a swivel so that the liquor can be run off from any height. Sometimes the "overflow" pipes are fitted on the outside of the boxes. The objection to this arrangement is that it causes a great amount of splashing

when the liquor is flowing, whereas if the “overflow” pipe is inside the box the liquor runs direct into the drain.

A combined “let-off” and “overflow” pipe can be arranged by fitting an iron collar on the “overflow” pipe two or three inches from the bottom. When the pipe is placed in position the collar fits over and completely closes the plug hole at the bottom of the box. When it is desired to empty the box the pipe is lifted out and the liquor flows into the drain.

THE DELIVERY WINCH.—The delivery winch should be double the width of the box in order to allow for the opening out of the warps. Engineers are inclined to make these winches on the small side but they are not so convenient as the wider ones.

CHAPTER X.

Hank Sizing and Bleaching.

HANK sizing is employed almost entirely for coloured and bleached yarns, and for grey yarns which are intended to be used in fancy coloured woven goods. This method is employed in sizing weft.

It is sometimes suggested that hank sizing is an obsolete method of incorporating size with the warp, but for certain classes of coloured woven goods it is still the best method to employ. For one reason the preparatory machinery used by many manufacturers of fancy coloured woven goods is adapted for treating yarns in the hank. There are also special cases where it is more advantageous to size in the hank than in the warp. For instance, some manufacturers bleach, dye, and size their own yarn. In such cases the manufacturer is able to keep a smaller stock of miscellaneous lots of dyed and sized yarns of various counts in the hank. This enables him to make a warp of any length at a very short

notice, especially where the pattern in the cloth requires a few ends only of certain colours.

There are some firms who not only bleach, dye, and size their yarns, but who finish the woven cloth for the market also. In such cases an endeavour is made, for obvious reasons, to keep the trade confined to as small a range of colours as possible. This is only possible to manufacturers of specialities. It rarely happens that there are more than seven or eight colours in one pattern, and this number is exceptional. As a rule there are not more than three or four colours. With these, together with the white and grey yarn, combinations can be obtained from which a great variety of patterns may be produced. Such firms as the above are exceptions, and as a general rule hank sizing, like ball sizing, is performed by the public dyer, to whom the manufacturer sends the grey yarns. The dyer has to lay himself out for the requirements of his different customers, and consequently he must be prepared to treat a very much greater range of coloured yarns than the manufacturer who dyes and sizes for his own trade.

In hank sizing it is customary to size the yarn at least twice, and in some cases three times. In the first operation an endeavour is made to incorporate as much size as possible with the yarn. For this purpose the size is always made stronger for the first operation than for the second and third.

In sizing grey yarns it is necessary to boil the hanks in water for several hours otherwise it would be impossible to size them successfully. The boiling operation removes the waxy and oily matters from the cotton to a great extent, and so allows the size to penetrate the threads. Sometimes the grey yarn is boiled in a 3 per cent. solution of washing soda instead of in water only. After boiling, the hanks are placed in the hydro-extractor, an illustration of which is shown on page 452.

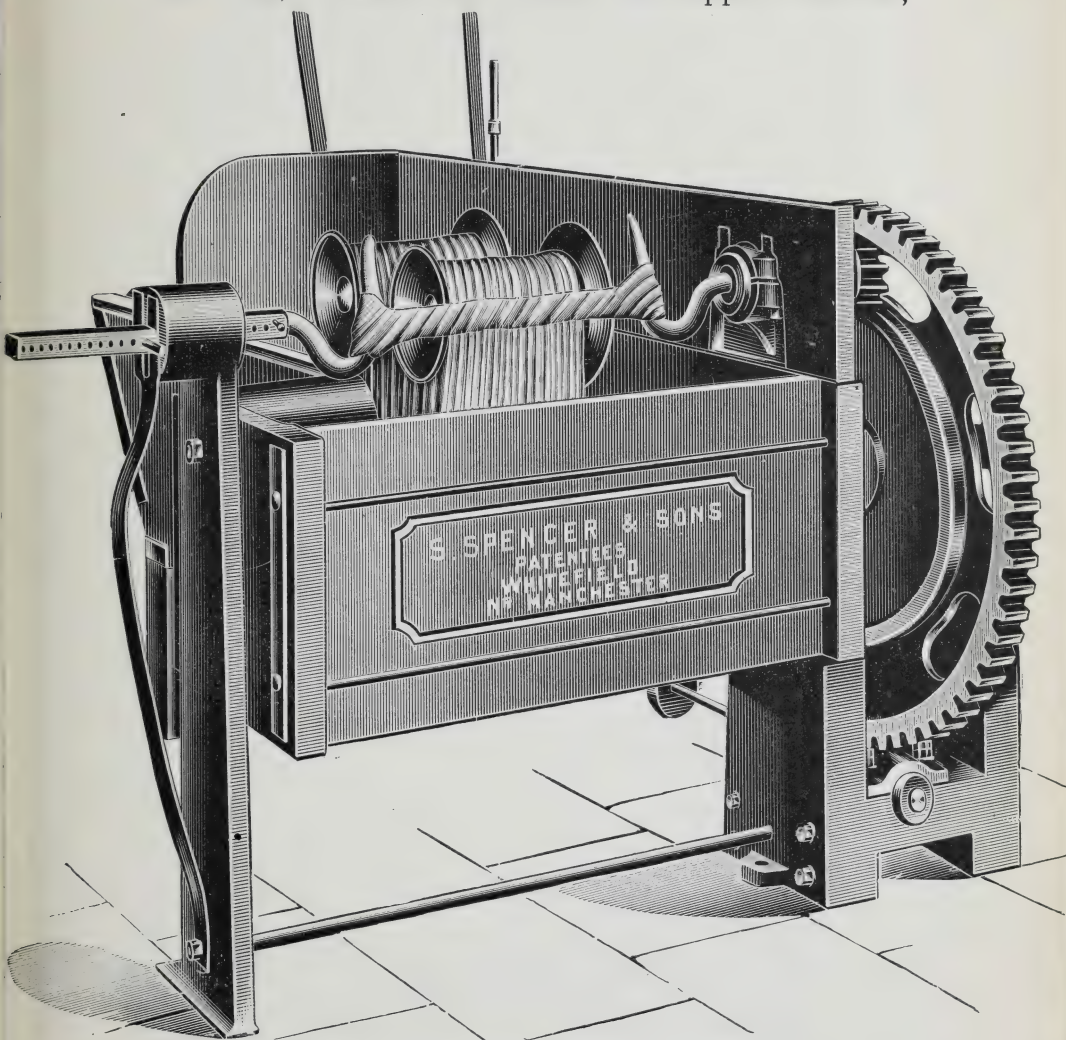
Coloured yarns are taken straight from the dye house and well treated in the hydro-extractor, after which they are sized. It is unnecessary to boil coloured yarns in water previous to sizing as the operations involved in scouring and dyeing render them fit to take the size without further treatment. Bleached yarns are treated in a similar manner to coloured yarns.

Hank sizing is essentially a light sizing process, and, as a matter of fact, it is considered very heavy if 10 to 15 per cent. of size is incorporated with the yarn.

HANK SIZING PLANT.

A great many improvements have been made in the apparatus employed for hank sizing in recent years, and the old slow process of sizing by hand has nearly passed away.

The machine used for hank sizing consists of a size box, in which are fitted two copper winches,



Single Hank Sizing and Wringing Machine.

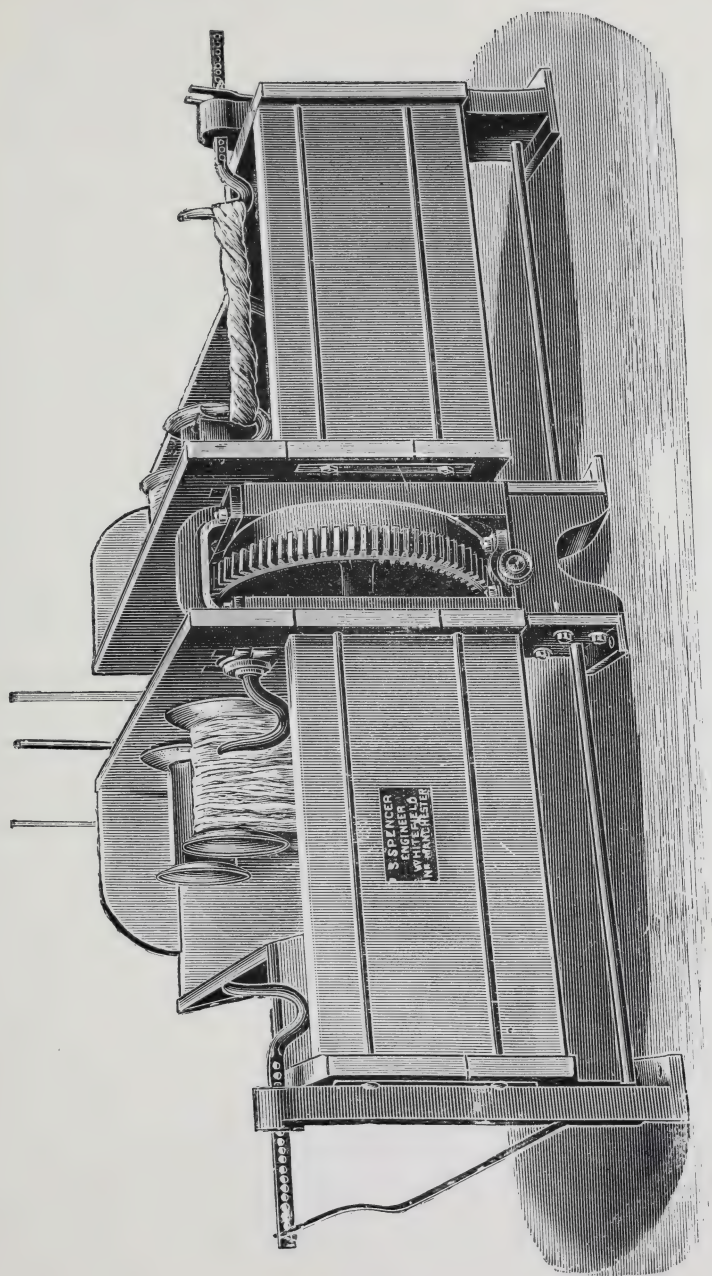
and two hooks. The winches, which are constructed in hexagonal form so as to get a better grip on the

yarn whilst revolving, are used for immersing the hanks of yarn in the size, and the hooks, which are made of steel, are used for mechanically wringing the hank after it has been sized. One of the hooks is fixed, whilst the other is arranged to revolve three turns.

An illustration of one of the best known hank sizing machines is shown on page 439. Another machine is illustrated on page 441. This is a double machine, and can be employed with advantage in many cases, as it allows two operatives to work at the same time. With this arrangement double the output can be obtained from the same mechanism for driving as from a single machine, and the employer is able to get work performed by one machine which would require two single machines with double the mechanism.

METHOD OF APPLYING THE SIZE.

The method of applying the size is as follows:— On receiving the yarn, the sizer proceeds to “head” it off in $1\frac{1}{2}$ -pound bunches or “noddles” (it is understood that the yarn has been already banded, previous to drying, etc., with a small band round every half-pound). He then takes 20 pounds of yarn and dips it into the size. After it has been immersed it is placed on a ledge constructed for the purpose in the size box. He then takes one bunch and places it on one of the revolving winches which



Double Hank Sizing and Wringing Machine.

immerses it in the size. As soon as the first bunch is on the winch he places a second bunch on the other winch. These are allowed to run for a few moments. The first bunch of yarn is then taken off and placed on the wringing hooks. One of the hooks is regulated by a pin so that the yarn may be wrung more or less tightly as may be required.

After wringing, the "sizer" runs his hand down the twisted yarn to remove the superfluous size. Whilst the wringing is taking place another bunch of yarn is put on the vacant winch, which is passed through the size as before. After wringing, the hook will take one turn back. This allows the "sizer" to take the yarn off the hooks, but does not entirely untwist it, because it is arranged to give three turns of the hook in wringing, and the machine stops automatically at one turn back. In this condition the yarn is easier to handle, and it is easier to find the middle when it comes to be shaken out.

The sizing machine is usually run at the speed of four "wringers" per minute.

METHOD OF MIXING THE SIZE.

The "mixings" used in hank sizing generally consist of flour, tallow and water. The flour should be a good pure wheaten flour, and all mixtures containing rice and maize flours should be strictly avoided.

It is not customary to steep or ferment the flour in hank sizing to the same extent as in ball and tape sizing. The general procedure is to mix sufficient for one or two days supply only. This is not an advisable method of treating the flour, as there is a danger of fermentation taking place on the yarn during the drying operation if the stove be a slow one, and not well ventilated. This would give rise to "soft" places.

It would be advisable in all cases to keep two becks for the flour, one beck for fermenting, and the other as a store beck from which the flour should be used. The flour is steeped in the proportion of 1 pound to 1 gallon of water. When a "mixing" is made, 20 gallons of the flour in steep should be run into a "mixing" beck, or tub, and 20 gallons of water added.

The "mixing," which is used at about 110 degrees Fah., or just sufficiently cool for the operative to handle in the machine, *should be well boiled* previous to being used.

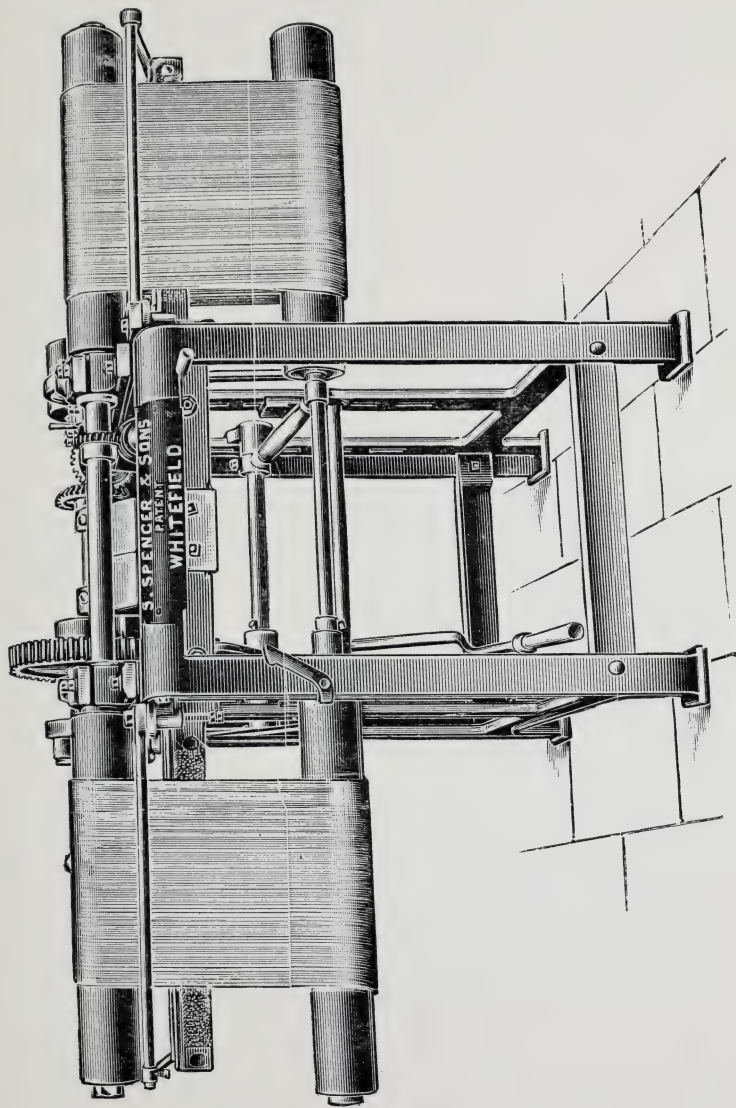
The sizer then runs into the machine say 5 to 10 gallons of boiled size, and 10 gallons of cold water, according to the "counts" of yarn. Through this mixture 20 pounds of yarn is passed. The size in the box is then "fed up" with 2 to 4 gallons of the boiled size. The operation of "feeding up" is repeated after every 20 pounds of yarn has been treated.

For the first time of sizing it is not customary to use tallow or other softener. In the second operation a "mixing" similar to the first, but weaker, is made. To this should be added from 1 to 2 pounds of tallow or paraffin wax. The strength of the size for the second operation depends upon the counts of yarn being treated, but it is always weaker than the "mixing" used for the first operation.

The yarn should not be overwring the first time of sizing, and it should be placed straight on the stove poles and dried. If the operation be properly carried out the yarn should come from the drying chambers very stiff and "boardy." It should be well wrung after the second operation. After wringing it is shaken out on the wringing or shaking post. The finer counts of yarn should be brushed either with a brush similar to a warp dresser's brush, or on a brushing machine, such as shown in the illustration on page 445. After brushing, it is carried on the "shaking stick" and placed open and straight on the stove poles to dry.

Grey yarn, after being boiled in water as previously described on page 438, is treated as above, but a stronger size should be used in this case.

During the sizing process, the hanks are liable to become disarranged. It is therefore necessary to straighten the yarn and "lay" the fibres, and, at the same time, stretch the hanks to something like



Brushing and Stretching Machine.

their original dimensions. This operation is performed after the final sizing, but it will be better described before discussing the drying operation.

For a long time brushing and stretching have been carried out by hand, but these operations may be more successfully carried out by means of the brushing and stretching machine shown on page 445.

The hanks are laid over the two sets of copper rollers. This is done by raising the lower set of rollers by means of a hand lever, shown in the illustration. A catch holds the lever in position until it is necessary to lower it.

The upper set of rollers revolves at a regular speed. The lower set are rotated intermittently by the action of the yarn, but they receive a vertically reciprocating motion which, at the upper end of the stroke (when the brushes are on the return stroke), takes the weight of these rollers off the hanks. This motion is effected by a cam not shown in the illustration.

Inside, and behind each set of hanks are reciprocating brushes so arranged that one set brushes one side and the other set the other side of the hank. Their movement is not quite vertical, for they come in contact with the yarn on the downward stroke only, and are quite clear of it when moving upward.

The brush motion is weighted to meet the heavy work put upon it at the times the brushes are

passing through the yarn, and so enables the machine to run at a regular speed. The brushing movement is arranged so as to cope with emergencies. In case of a "felter" in the yarn, through which the brushes would not pass without breaking the threads, the brushes "give," and thus avoid causing damage. The rollers, or arms, work in a parallel motion, thus stretching the yarn evenly. The position of the lower set of rollers is adjusted by the length of the hank, of which various sizes can be taken without altering the machine.

The speed of this brushing machine is very high and the output from it is very large.

After sizing, the hanks are dried in the stove. The stove used for this purpose is generally a brick building, with one or two floors. Each floor usually contains two tiers. The floors are constructed of iron gratings, so that the air may pass upwards from the basement and out at the top of the building through a ventilator.

The drying operation is generally carried out at night so that the hanks may be ready for re-sizing the next day. Drying by means of a stove, or hot-air chamber, is not an ideal method, as it often leads to damage through the hanks becoming "soft." This damage is caused through the air being insufficiently circulated through the stove. The conditions suitable for bacterial development are

provided by the moisture and the high temperature, and the size loses its adhesiveness. If this occurs the operation of sizing has to be repeated, otherwise the yarn would not weave. The damage would not take place in a well ventilated stove, and for this reason fans are very often employed to remove the air. This is not always convenient, however, on account of the difficulties of driving. There is a further objection to the use of fans in large manufacturing centres. The fans draw into the stove particles of soot and dirt, and unless the air be filtered these particles are deposited on the yarn.

There are several firms in this country who are making an improved form of drying apparatus. The chief advantages are that the drying can be carried out in the day-time, and there is less liability to produce "soft" yarn. Such apparatus is also free from the troubles caused by the use of fans as previously mentioned.

Such in brief are the chief operations involved in hank sizing, but the success of the operations depend mainly on two conditions, the first is that the "sizer" should be a man who knows his work, and the second is that the ingredients should be suitable. However skilful a workman may be he cannot get good results from unsuitable ingredients, and however suitable the ingredients may be good results cannot be got unless the "sizer" knows his business.

It has already been stated that a pure flour of good quality should be used, and it has also been mentioned that the size mixing should be well boiled. Better results would be obtained in hank sizing if manufacturers would put down suitable plant for steeping the flour so that the starch could be properly separated from the gluten as is done in tape sizing. Most of the troubles of hank sizers are due to the use of unsuitable ingredients or to unsuitable methods of treating the ingredients.

HANK BLEACHING.

The process of bleaching in the hank is carried out as follows :—

The hanks are first tied up into bundles of 10 lbs. each and afterwards boiled in the open kier with a solution of soda ash and caustic soda as described on page 424. The bleaching operations may be summarised as follows :—

- 1st.—Kier boiled for about 10 to 12 hours with soda ash and caustic soda.
- 2nd.—Washed with water in the kier.
- 3rd.—“Chemicked.”
- 4th.—Washed with water in the “chemic” cistern.
- 5th.—“Soured” in acid in the “chemic” cistern.
- 6th.—Washed with water in the “chemic” cistern.
- 7th.—Soaped and “blued.”
- 8th.—Treated in the “stocks” or in the “dumper.”
- 9th.—Washed with water.

After boiling in the kier the liquor is drained off. The first washing is conducted in the kier and the wash water drained off as far as possible. The top bundles may then be placed in the "chemic" cistern, as they will be sufficiently dried for treatment, but the bottom bundles must be hydro-extracted, otherwise the bleaching liquor will not penetrate the yarn, and the excess of water contained in the hanks would dilute the bleaching liquor to such an extent as to make it inoperative.

When the bundles of yarn have been placed in the "chemic" cistern, the bleaching liquor, which should be used at about 1° Tw., is sprayed or showered over them by means of a pump for three or four hours, according to the weight of yarn undergoing treatment.

After "chemicking" the hanks are allowed to drain thoroughly and then water is showered over them by means of the pump in order to remove the last trace of "chemic." The washing operation should be carried out at intervals, as better results can be obtained by working the pump for 20 minutes, allowing the washing liquor to drain off well and afterwards pumping fresh water over, than can be got by working the pump continuously. This method effects a considerable saving in the water also.

After washing off from the "chemic" the hanks are "showered" with acid, Twaddelling about 1° Tw. This operation is conducted in the same cistern as

that used for "chemicking" and washing, and should be continued for about an hour, according to the weight of yarn undergoing treatment.

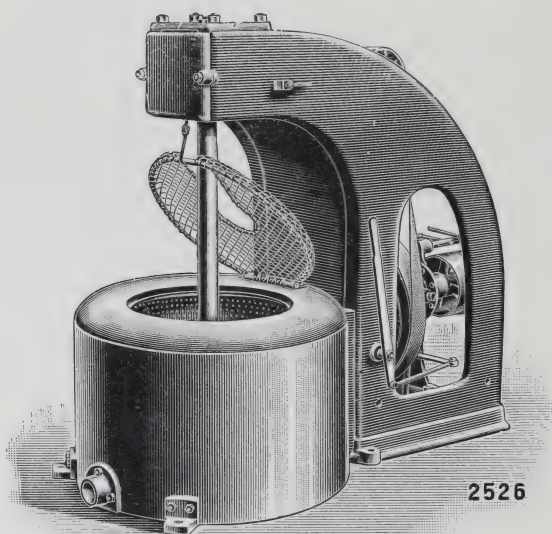
After "souring," the hanks are allowed to drain well, and afterwards thoroughly washed, as previously described, in order to remove all trace of acid. They are then soaped and "blued" if required. From the soap bath the hanks are placed in the "stocks" where they are beaten or pounded by wooden beaters for some time. This operation is very effectual for removing the last trace of dirt. After "stocking," the hanks are washed and drained, and finally treated in the hydro-extractor. This latter operation is absolutely essential as the yarn would be too wet to size after draining only. The excess of water would weaken the size to such an extent as to cause the yarn to come up "soft." Not only would this be the case but it would be impossible for the size to penetrate yarn saturated with moisture. An illustration of one of the best types of hydro-extractors is shown on page 452.

The hydro-extractor is a machine employed for removing water or other liquid from some material by the action of centrifugal force.

The material from which the water has to be extracted is put into a cylindrical vessel, usually called the basket of the machine, the shell or periphery of which is perforated. The basket is then revolved at a high speed and the centrifugal

force presses the material against the shell, thus expelling the water through the perforations into a suitable outer case.

These hydro-extractors may be either of the pivot or under-driven type, or of the suspended or over-driven type, but when a large machine is required the suspended type is preferable. Either



Suspended Type of Hydro-Extractor.
Watson, Laidlaw & Co. Ltd., Glasgow.

type of machine may be driven by belt from a shaft, or by an engine, or by an electro motor. The suspended machines may also be driven by an electro motor coupled direct to the extractor spindle.

The electro motors are totally enclosed to permit them being worked in a damp atmosphere, and either

continuous current or alternating current motors may be used.

The machines may also be driven by a water motor coupled direct to the extractor spindle. The water pressure is usually from 150 to 200 lbs. per square inch and supplied by a pump put in for the purpose. In some instances the pump required for the fire extinguishing apparatus is used.

In the direct electrically-driven machines, and those driven by water, there is an entire absence of belting and shafting, which is a great advantage as they may be placed in any convenient position independent of shafting, and the work done by the machines driven in any of the described methods is the same.

In the machine illustrated, all the parts are above the ground level, and, as they are self-balancing, a special foundation is not required. The machines may also be placed on any upper floor which will carry ordinary machinery of like weight.

The self-balancing feature is obtained by embracing one end of the spindle in an indiarubber buffer or cushion placed at the top of the spindle in suspended machines, and at the lower end in pivot machines. This buffer, which is patented, is conoidal in form, and it is a great improvement over forms of buffers hitherto used. Not only is it self-adjusting, but it controls the oscillations of the machine better than other types.

The spindles are made in one piece, and the load and side pressure is taken by an arrangement of ball bearings. There are no brass bushes and the ball bearings do not require to be lubricated in the ordinary sense. It is only necessary to have sufficient grease on them to prevent rusting. In this condition they will run for several months without requiring the supply of grease to be replenished.

The baskets in the type of machine shown in the illustration hold more than those of other makes because they have no cone in the centre. They have wider lips and they are also deeper, especially the suspended machines, than those of the pivot type. The baskets of the former type are also deeper.

The pivot machines are made with the following diameters of baskets:—18, 21, 24, 27, 30, 36 and 42 inches, while the usual sizes of suspended machines are 24, 30, 36, 42, 48, 54 and 60 inches, but special suspended machines are also made with baskets 72 and 84 inches diameter.

CHAPTER XI.

*The Preparation of the Yarn for the
Process of Weaving,
and
The Testing of Sized Yarns.*

THE preparation of the yarn previous to its being woven into cloth demands more care and attention than the actual process of weaving. Careless treatment of the yarn in the winding and warping operations entails extra work by the weavers. Big knots taken up carelessly in winding, or lost ends, and bad sides in warping, are a few of the faults which tend to increase the weaver's work. If, in addition to these faults the yarn has been badly sized, or if the "elasticity" has been taken out of it through too much tension, or worse still, if it has been dried to such an extent as to deprive it of the greater portion of its natural moisture, the weaver will have still further trouble. At the same time there is no method of sizing known by which bad or indifferent yarn can be made to weave as well as good yarn, nor has any method of applying the size, or any special sizing ingredient been

discovered, which will enable "heavy" sized yarn to weave as well as "pure" sized yarn. Anyone who can discover such a process, or such a sizing ingredient, will be a benefactor to thousands in Lancashire.

The aim and object of all operations involved in the preparatory processes should be to treat the yarn in such a manner as to get rid of its defects, such as lumps, loose ends, and weak places. At the same time every possible precaution should be taken to keep the strength and "elasticity" unimpaired. If only a little more time and thought were devoted by all operatives to considering the welfare of those who follow them in the after processes, the quality of work would be improved all round. No single operative can do more towards this end than the "taper." He can see by the appearance of the yarn as it travels along the headstock whether the lumps and loose ends have been taken out. The number of "lappers" on the backbeams will also give him an idea as to the quality of the yarn and the relative merits of the different warpers for making good work.

Weavers cannot, as a rule, understand that "ends which come up broken" are due to careless warpers taking "ends" up "crooked," and so causing "lappers." The taper gets the blame for this, and all tapers would be acting in their own interests and in the interests of their employers if they tried

to keep the warpers' work up to the highest possible standard.

If the automatic loom has to be introduced into Lancashire with a view to decreasing the cost of production by increasing the number of looms per operative, the quality of the work on the weaver's beam will certainly have to be improved. How much of this improvement can be obtained by reducing the speed of the machinery remains to be seen. Without doubt the whole of the machinery in the weaving department is being run at a high speed with a view to producing the maximum amount of work *per machine* in a given time. Whether this speed is the right one for obtaining a maximum output *per operative* is another question altogether. If the speed of the warping mills and the looms were decreased the amount of labour expended in piecing broken yarn would certainly be considerably reduced. At the same time it must not be forgotten that however much the speeds of these machines are reduced, or how careful each operative may be, the chief requisite for producing a perfect weaver's beam is good strong yarn.

Lancashire manufacturers have endeavoured to produce cloth which shall have as full an appearance as it is possible to obtain from the counts of yarn woven into it. In order to produce this condition it is essential that the yarn shall be spun with less turns per inch than is required for producing a yarn

possessing the maximum strength. The strength of the yarn is thus sacrificed in order to obtain an increased diameter of thread. Yarn of this description may give a "full" appearance to the cloth, but it is responsible for an enormous amount of unnecessary work to those engaged in manipulating it. The cloth may look better but it probably does not wear so well. The number of extra ends pieced by winders, warpers, and weavers, through the use of this soft, and often unevenly twisted mule yarn, is undoubtedly a waste of energy which might be put into more remunerative channels.

If operatives are expected to superintend more machines it is evident to the authors that the "full" appearance of the cloth will have to be taken less into consideration, or this appearance will have to be produced by some process after the cloth is woven.

Ring spun yarn does not give so full an appearance to the cloth as mule spun yarn. It contracts more in length during the process of weaving, and it also requires a stronger size than mule spun yarn to put a given percentage on the yarn. On the other hand it is more uniform in diameter, strength, and turns per inch. Its breaking strain is also higher, and it contains a less number of thin and soft places. For these reasons it weaves with less breakages than the average mule yarn, and it is therefore more suitable for an automatic loom.

In order to reduce the amount of labour required in all the processes involved in the weaving section of the cotton industry to a minimum, it will be necessary that the yarn shall be evenly spun and free from "snarls," in order to obtain the maximum amount of strength uniformly distributed throughout its entire length.

THE TESTING OF SIZED YARNS.

Efforts have been made at various times to introduce a system for testing yarn before and after sizing for "elasticity" and strength. The differences are generally given in terms of "percentage of gains in strength," and "percentage loss or gain in elasticity."

For the purpose of testing yarns many machines have been placed upon the market, but whatever merit they may possess when employed for testing the strength of *unsized yarn*, they are of no practical use for testing the *weaving qualities* after it has been *sized*. There are many points to consider when testing the *weaving qualities* of a *sized* yarn besides the breaking strength, and the only reliable test is the actual weaving of the yarn into cloth. The usual method adopted by the manufacturer is to note the "feel" of the yarn after it has been sized. This, together with careful observation as to the manner it weaves in the shed, are the only reliable tests which can be applied as yet.

The authors are strongly of the opinion that the results obtained with any type of testing machine are not a reliable indication of the *weaving qualities* of the yarn. In the first place the amount of size present affects the results shown on the testing machine. Thus, if the yarn is "pure" sized the "gain in strength," as shown by the testing machine, will depend to a very great extent upon the amount of size which has been incorporated with it, the greater the percentage of size and the greater will be the apparent "gain in strength." It does not necessarily follow, however, that if 5 per cent. of size on the twist is sufficient for a certain class of cloth that it is advantageous to size it to the extent of 10 per cent. The latter amount of size would show a better result when tested on the testing machine, but this does not mean that it would *weave any better*. All practical sizers know that it is necessary to size yarn according to the class of cloth it is intended to produce. For instance, size which would be suitable for a fine reed and a large number of picks would not be suitable for a coarse reed and a correspondingly lower number of picks. In the former case the size would require to be stronger than in the latter. But if a strong size were used for a coarse reed and a low pick, thus giving a greater percentage of size, it would not weave as well as a weaker size, nor would it produce a cloth

with as good a "cover," although it would show a greater breaking strength on the testing machine.

The term "elasticity" has been used in the previous chapters of this book on many occasions. The authors have used the term simply because it is a customary one. At the same time it is not correctly used when applied to the testing of yarns.

"Elasticity" means the power possessed by bodies to return to the form from which they have been bent or distorted. In testing yarns for what is termed "elasticity," it is usual to stretch the yarn until it breaks. In other words the "elasticity" is confounded with the breaking strain.

The difference in length between the yarn in its natural condition as a thread, and the distance it will stretch before breaking, should, in the opinion of the authors, be termed "the percentage of elongation," and not "the percentage of elasticity."

The amount of "elongation" depends upon several conditions. It is governed in the first place by the length of the fibres which compose the thread; in the second place by the evenness and the number of turns of "twist" imparted to the thread; in the third place by the percentage of size incorporated with the yarn, and lastly by *the amount of moisture contained in the yarn at the time it is tested.*

The authors know of many instances where samples from the same yarn have given entirely different results when tested on the same machine.

They also know many cases where yarns have been tested, and the samples showing the worst result on the testing machine have given the best results in the weaving shed, and vice versa.

Not only do the majority of the testing machines give results which are unreliable for practical working, but they *all* fail to take into consideration one of the most important factors in the weaving quality of a well sized yarn, viz.:—*its pliability*.

The pliability of a sized yarn determines to a great extent its weaving qualities. The difference shown in the weaving of the same yarn on a dry windy day and on a calm moist day is due entirely to the difference in the pliability of the yarn on these days. During the process of weaving the yarn is being bent continually from the point where it gets to the shed rods to the point where it reaches the fell of the cloth. No matter how strong the yarn may be it will not weave satisfactorily if it does not possess the necessary pliability. In this respect it may be compared with the results which would be obtained if a piece of strong cardboard were tested for breaking strength against a piece of tissue paper. The cardboard would be far stronger if subjected to a straight pull but if they were tested for breaking strength by bending each at right angles the tissue paper would show a much better result than the cardboard.

CHAPTER XII.

*The Physical and Chemical Properties
of Cotton,**and the**Chemical Examination of Textile Fibres*

COTTON forms the seed hairs of various kinds of *Gossypium* of the natural order *Malvacæ*. The most important species are:—

1. *Gossypium herbaceum*.—This is an annual shrubby plant, about three feet high, indigenous to Asia and Egypt. A drawing of this plant is shown on page 464.

2. *Gossypium barbadense*.—This plant reaches a height of fifteen feet; indigenous to the West Indies.

3. *Gossypium religiosum*.—This species has a brownish yellow fibre; indigenous to India and China.

4. *Gossypium hirsutum*.—The hairy American cotton grows to a height of about six feet. It is largely cultivated in North and South America.

The fibres of cotton are unicellular, consisting of hollow tubes. They are easily recognised by means of the microscope, and readily distinguished from



Cotton Pod and Flower of *Gossypium Herbaceum*.

other fibres such as flax and jute hemp. The diameters and lengths of the fibres vary very considerably in different kinds of cotton.

LIST OF MAGNIFIED TEXTILE FIBRES.

- No. 1.—Plate XV Magnified Cotton Fibres.
- No. 2.— „ XVa „ Mercerised Cotton Fibres.
- No. 3.— „ XVb „ Dead Cotton Fibres.
- No. 4.— „ XVI „ Flax Fibres.
- No. 5.— „ XVIa „ Hemp Fibres.
- No. 6.— „ XVII „ Jute Fibres.
- No. 7.— „ XVIIa „ Wool Fibres.
- No. 8.— „ XVIIb „ China Grass (Ramie) Fibres.
- No. 9.— „ XVIII „ Raw Silk Fibres.
- No. 10.— „ XVIIIa „ Viscose Fibres.
-

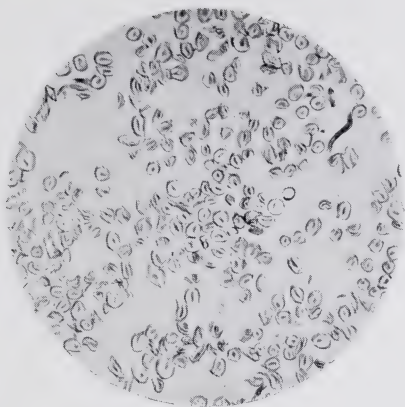
Photographs and Drawings by
FLATTERS, MILBORNE & McKECHNIE LIMITED, MANCHESTER.



Transverse Section of Cotton Fibre $\times 100$.



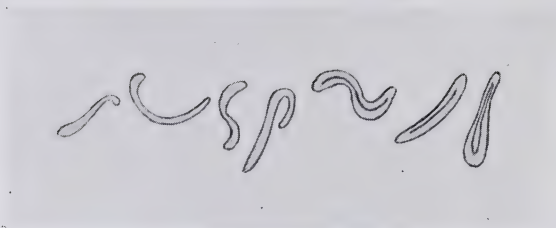
Cotton Fibre $\times 100$.



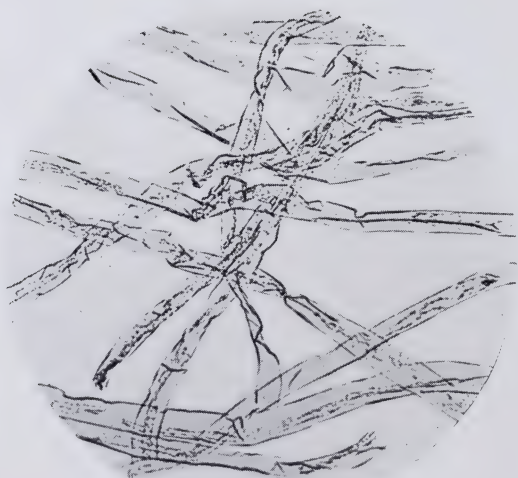
Transverse Section Mercerised Cotton Fibre $\times 100$.



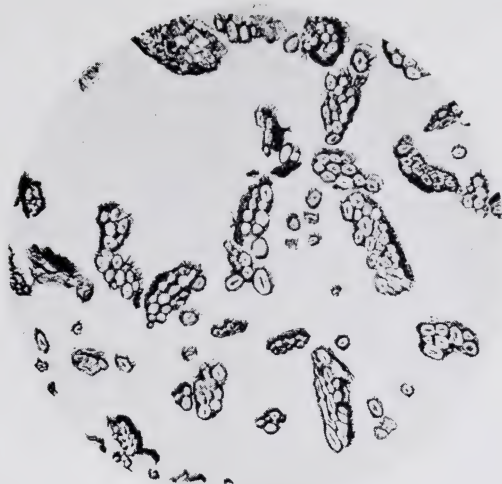
Mercerised Cotton Fibre $\times 100$.



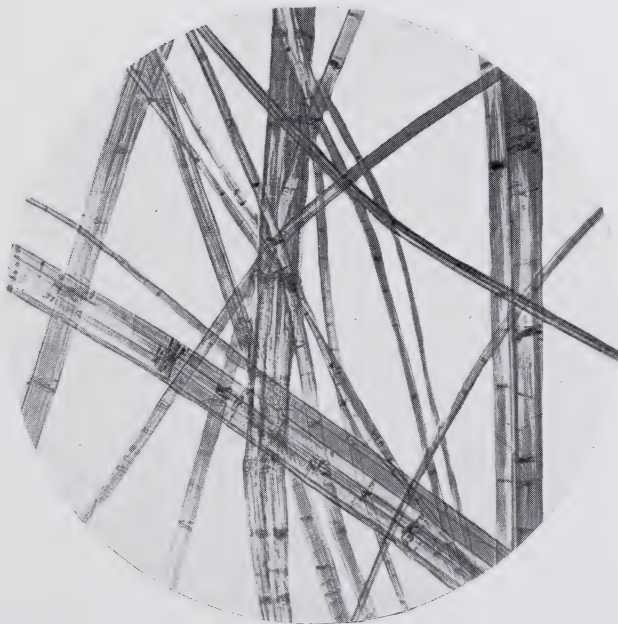
Transverse Section of Fibres of Dead Cotton $\times 100$.



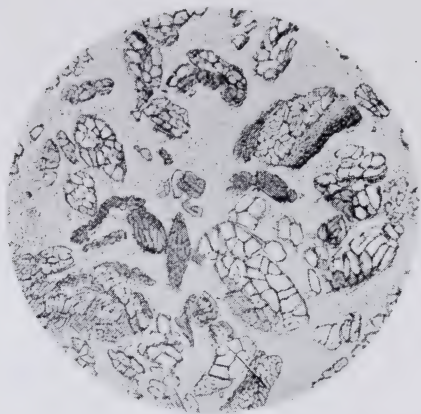
Photomicrograph of Dead Cotton $\times 75$.



Transverse Section of Flax Fibre $\times 100$.
In natural bundle masses.



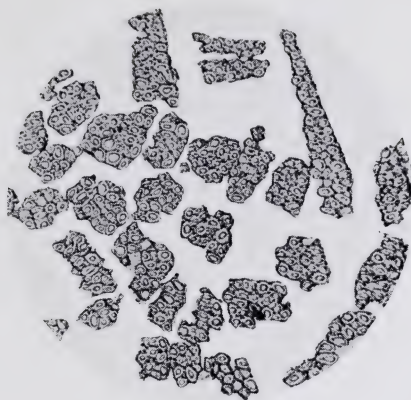
Flax Fibre $\times 100$.
Fibres partially separated.
Plate XVI.



Transverse Section of Hemp Fibre $\times 100$.
In natural bundle masses.



Hemp Fibre $\times 100$,
Reduced to single Fibres.
Plate XVIa.



Transverse Section of Jute Fibre $\times 100$.

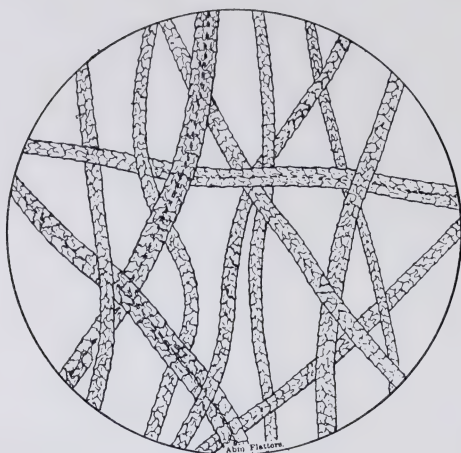
In natural bundle masses.



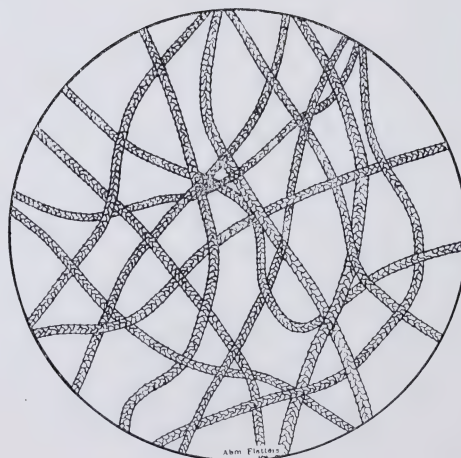
Jute Fibre $\times 100$.

Reduced to ultimate Fibres.

Plate XVII.



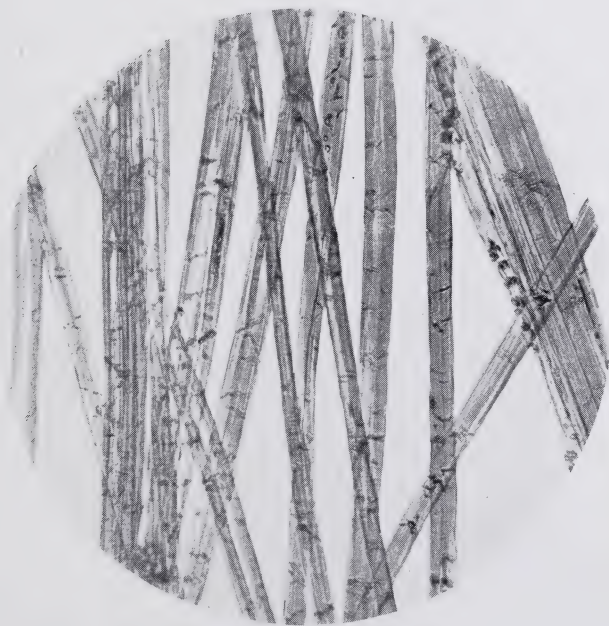
Lincoln Hog $\times 65$.



Wool Saxony $\times 65$.



Transverse Section China Grass (Rhamie) $\times 60$.



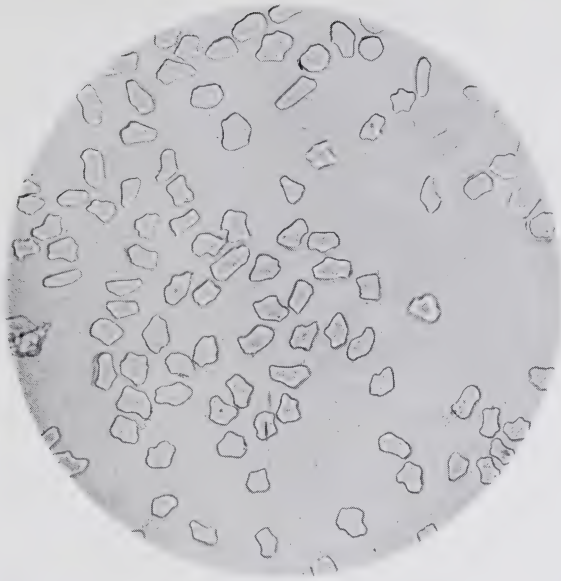
China Grass (Rhamie) $\times 60$.



Transverse Section of Raw Silk $\times 200$.



Entire Fibre of Raw Silk $\times 75$.



Transverse Section of Viscose Fibres $\times 100$
(Artificial Silk.)



Entire Fibres of Viscose $\times 100$
(Artificial Silk.)

The following table will give the reader some idea of the average size of the different classes:—

	LENGTH.	DIAMETER.
South Sea Islands.....	1'68 inch	$\frac{1}{1562}$ of an inch.
Egyptian	1'25 "	$\frac{1}{1526}$ "
United States	1'00 "	$\frac{1}{1290}$ "
Indian	0'94 "	$\frac{1}{1185}$ "

Cotton used for "heavy" sized yarn should be medium in length of staple, and should not be too tightly spun. American cotton is almost invariably used for this purpose.

Chemically, cotton fibre, separated from all impurities, may be looked upon as pure cellulose similar in chemical composition to the cellulose in starch and wood, and having the same approximate composition, usually expressed by the empirical formula $C_6H_{10}O_5$. The following is the percentage of the elements, carbon, hydrogen, and oxygen, which, chemically combined, form cellulose :—

Carbon	44'44
Hydrogen	6'17
Oxygen	49'38
	<hr/>
	99'99
	<hr/>

Ordinary raw cotton is not pure cellulose. It contains various impurities such as wax, oil, colouring matter, water, and about one per cent. of mineral matter.

The following may be taken as the average percentage composition of ordinary raw cotton :—

Pure dry cellulose	87
Wax, oil, colouring matter	4
Mineral matter, as ash	1
Natural moisture.....	8
	<hr/>
	100
	<hr/>

CELLULOSE.—The cellulose of cotton consists of the cuticula, or skin, and cellulose proper. This is shown by the action of ammoniacal copper oxide solution which dissolves the cellulose, causing it to swell up, leaving the cuticula broken but unchanged. On adding sulphuric acid, and afterwards a drop of solution of iodine, the cellulose is coloured blue, the broken cuticula yellow.

Cellulose is insoluble in cold or hot water, in dilute acids or alkalies, in ether, alcohol, fats, or volatile oils, but it is readily dissolved in concentrated sulphuric acid, and in *very strong* solutions of caustic alkalies. A very interesting fact is that cellulose has the property, when immersed in solutions of weak mineral acids, of absorbing and condensing the acid within itself at the expense of the surrounding liquor, which is made weaker in consequence. This is an important matter to the bleacher, showing that strong solutions of acids must not be used nor must the cloth remain long in contact with the “souring liquor,” even when dilute.

Dilute mineral acids as previously stated do not attack the cellulose of cotton, but if the fabric containing weak acid be subjected to dry heat tendering takes place.

Cellulose is not effected by milk of lime either hot or cold so long as it be immersed in the liquid, but if the lime be allowed to dry on the fibre, or if the fibre be exposed to the atmosphere, it soon tenders through the formation of oxycellulose. This is a matter which is also of the greatest importance in the bleaching of cotton and linen cloth.

MINERAL MATTER.—The mineral matter in cotton as previously stated, is about one per cent. The following analysis of the ash shows its average composition:—

Carbonate of potassium.....	44'80	} Soluble in Water.
Chloride of potassium	9'90	
Sulphate of potassium	9'30	
Phosphate of magnesium	8'40	} Insoluble in Water.
Phosphate of calcium	9'00	
Carbonate of calcium	10'60	
Peroxide of iron.....	3'00	
Alumina, traces and loss	5'00	
	<hr/> 100'00 <hr/>	

The above analysis represents the ash after burning. It is highly probable that the phosphoric acid is combined with some of the potassium, and the magnesium with hydrochloric acid, as all natural cotton yields from 0'04 to 0'08 per cent. of chloride of magnesium when digested with distilled

water. This together with the carbonate of potassium accounts for the hygroscopic nature of natural cotton.

OIL, WAX, RESIN, ETC.—These substances, together with certain soluble matters, are found in and upon raw cotton to the extent of about four per cent. It is due to the presence of these waxy and oily matters that raw cotton and unbleached cotton yarns and cloth are so difficult to wet through with water.

The late Dr. Edward Schunck of Manchester examined raw cotton with a view to determine the nature of the substances contained in cotton fibre other than cellulose. Dr. Schunck found amongst other substances a wax which he called cotton wax. This has a melting point of over 186° Fah. He also obtained a white solid fatty acid, having a melting point of 132° Fah.; two distinct colouring matters, one soluble the other insoluble in alcohol; pectic acid, and albuminous matters. Most of these substances are practically insoluble in water, and it is on this account that the principal processes in bleaching consist of operations designed to remove the resinous, oily, and waxy substances. They protect the colouring matter of the cotton from the action of the chlorine used in the latter stages of bleaching. Some proportion of the waxy and oily matter is removed during the process of spinning and a further quantity when the cloth is treated with boiling water. The heat causes the wax to melt, and it is carried away mechanically.

NATURAL MOISTURE.—The amount of natural moisture in cotton is eight per cent. That is, in every 100 parts by weight of cotton there are eight parts by weight of water. If raw cotton or unbleached cotton yarn be dried it very quickly absorbs moisture on exposure to the atmosphere. This is due to the presence of deliquescent salts in the mineral matter contained in the fibre. It is a well-known fact that cotton which has been boiled with caustic soda and afterwards “soured” in hydrochloric acid does not absorb water to the same extent as raw cotton, or as cotton yarn which has been simply dried. Cloth which has been bleached loses a great amount of its hygroscopic nature. The bleaching operations remove the deliquescent salts, and thus prevent to a certain extent the cloth taking up moisture when it is exposed to the atmosphere. To such an extent does bleached cloth lose its power of rapidly absorbing moisture that it is essential to pass it over a damping machine before it can be starched and “finished.”

In the process of spinning a large proportion of the natural moisture is removed. In order to regain the weight which has been lost it is customary for the spinner to moisten, or, as it is called, to “condition,” the yarn before it is sent to the manufacturer. If this “conditioning” were carried out simply for the purpose of replacing moisture which had been removed in the spinning process there would be no

objection to it, but unfortunately it is the custom of some spinners to add as much water as they can with the object of selling water in place of cotton yarn. From this it will be seen that cotton yarn, as received from the spinner, may contain anything from 8 to 15 or 16 per cent. of water. Anything above eight per cent. is water which has been added after the cotton has been spun into yarn. It would be to the advantage of the manufacturer if he would regularly test the cops for the amount of water contained in them. All added water is lost when the yarn is passed over the drying cylinder of the tape frame, consequently the manufacturer pays for something which does not appear in the woven cloth.

It has become the practice in recent years for certain spinners to treat their yarns with deliquescent chemicals, such as the chlorides of magnesium, calcium and zinc, for the purpose of increasing its powers of absorbing moisture. These chemicals also assist in preventing the moisture drying out. This practice cannot be too strongly condemned as it is certain to cause serious damage to cloth which has to be singed previous to bleaching. Not only is there a liability to damage if the cloth has to be bleached, but there is also the loss to the manufacturer through shortage in length. The authors know of many instances where the above chemicals have been used by the spinner and where serious loss has been

caused to the manufacturers. In many cases suspicion has been aroused by the yarn sticking and breaking during winding. The operatives have complained about the quality of the yarn, whereas the cause of complaint has been the presence of the substances just mentioned.

The over-damping of cotton yarn has been carried to such an extent that mildew has actually developed on the "cops" before they have been woven into cloth. To prevent this evidence of over-damping being shown spinners have employed crude carbolic acid and other antiseptics. Where crude carbolic acid has been used stains have actually shown on the "cops" where they have come in contact with the "damping" cloths through the presence of tar oil in the carbolic acid.

There is another serious aspect to this question of "over-damp" yarn, and that is its liability to cause mildew when it is woven into cloth. This applies more particularly to weft than to warp, because the warp yarn is boiled during sizing, and in this way prevents further development of the mildew. It will be readily understood that if mildew is already present in the weft and is woven into a "pure" sized cloth in which chloride of zinc is not employed in the size, mildew is certain to develop and spread through the whole cloth. The weft may not show any actual signs of mildew when casually examined, and no apparent damage is

shown until it comes in contact with the starchy matter on the warp. The starch will form an excellent medium for it to develop and spread, and the cloth will be entirely ruined. This effect may not be produced for some time after it is woven, and then it will be almost impossible to prove how the damage has occurred. Generally the taper is blamed for not drying the yarn sufficiently.

If manufacturers would unite and make a firm stand against this practice of over-damping yarns it would be greatly to their advantage. If it were made a condition that all excess of moisture over 8·5 per cent. would be claimed on, by deducting from the spinners' account, the practice would very quickly cease.

PHYSICAL EXAMINATION OF TEXTILE FIBRES.

It is necessary to employ the microscope in order to determine the nature of the fibre from which a yarn has been spun. Chemical tests may be employed also, but the microscopic examination is generally the more trustworthy.

VEGETABLE FIBRES. COTTON, FLAX, AND HEMP.

The fibres of the above substances are shown to differ considerably in structure when viewed with the aid of the microscope.

COTTON.—Under the microscope, cotton fibre appears as a wide band, generally twisted as shown on *plates xv. and xva.*

FLAX.—LINEN.—Flax is composed of the bast fibres of the stem of the flax plant (*Linum usitatissimum*). The fibres consist of chemically pure cellulose, and are of regular thickness. The cells are built up in a regular manner, cylindrical in shape, having the *nodes* arranged at regular intervals. An illustration of magnified linen fibres is shown on *plate xvi.*

HEMP.—Hemp is composed of the bast fibres of the stem of the hemp plant (*Cannabis sativa*). The cells are very irregular in form, and do not possess *nodes* as in the case of flax. The cell walls are not of such constant thickness as flax, and the ends of the fibres are blunt, having thick walls, frequently branching laterally. An illustration of magnified hemp fibres is shown on *plate xvii.*

Hemp is used principally for the manufacture of ropes, sacking, canvas, etc. It is eminently suited for this purpose on account of its strength. It does not readily rot when in contact with water. Hemp is rarely bleached, for although this is possible, the coarseness of the material renders it unsuitable for clothing.

JUTE.—Jute is obtained from the bast fibres of the stems of several kinds of *Corchorus*, especially *Corchorus capsularis* and *Corchorus olitorius*. The

fibre has a whitish yellow colour but turns brown on ageing. The cell walls are irregular in thickness and the internal and exterior border lines are not parallel. An illustration of magnified jute fibres is shown on *plate xvii.*

ANIMAL FIBRES.

WOOL AND SILK.

WOOL.—Wool is obtained principally from the hair of the sheep, the goat, and the camel. The appearance of wool under the microscope is shown on *plate xviii.*

Wool differs very considerably in chemical composition from cotton and flax. It consists of horny matter (keratin), carbon, hydrogen, oxygen, nitrogen, and sulphur. This composition is most strikingly noticed when wool is burnt. The peculiarly disagreeable smell of burning horn is given off. Boiling caustic soda or caustic potash solutions readily dissolve wool. If acetic acid in excess be added to the solution obtained, sulphuretted hydrogen is given off.

Wool is very hygroscopic. The amount of moisture found in woven cloth varies from 15 to 18.25 per cent. and this amount is allowed officially on the Continent for army clothing contracts.

SILK.—This fibre is obtained from the larvæ of various insects, and it is that with which they surround themselves before entering the pupal stage. The cocoon, or envelope thread, is the

result of the hardening of the fluid ejected from the serecteria of the larva.

Silk exhibits no definite structure, but consists of cylindrical or flattened, sometimes helical, compact threads. It is chemically composed of silk gelatin, silk fibre, with fat, resin, colouring matter, and mineral substances. When viewed under the microscope silk appears as a smooth cylinder without any contents.

CHEMICAL EXAMINATION OF TEXTILE FIBRES.

Vegetable fibres may be readily distinguished from animal fibres by burning.

ANIMAL FIBRES, such as wool and silk, give off the smell of burnt horn. They do not fire like vegetable fibres, but cease to burn when removed from the flame, and the burnt portion curls up, forming a hard cinder at the end of the thread.

VEGETABLE FIBRES, on the other hand, give off a slight smell of burnt wood when ignited. They burn away very rapidly with a flash, leaving no hard cinder, but a white or grey ash only.

The above test broadly distinguishes vegetable from animal fibres, but further chemical examination is necessary to distinguish mixtures of any of them when woven into cloth.

The following solutions will be required for making the chemical tests. :—

1. Ammoniacal Copper Oxide Solution.
2. Ammoniacal Nickel Oxide Solution.
3. Chloride of Zinc Solution.
4. Iodine Solution.
5. Fuchsine Solution.
6. Nitric Acid, Commercial.
7. Sulphuric Acid, 58°B strength = 134°T.
8. Hydrochloric Acid, 3 per cent.
9. Caustic Soda Solution, 0·1 per cent.
10. Caustic Potash Solution, 10 per cent.
11. Caustic Soda Solution, sp. gr. 1·05.

SEPARATION OF WOOL AND COTTON IN A MIXED FABRIC.

A weighed portion of the fabric is dried in the water oven until all moisture is driven off. It is then weighed in a stoppered glass tube, as described on page 492, and the amount of loss calculated to a percentage.

The dried cloth, the weight of which is known from the last operation, is boiled, first with *very dilute caustic soda solution* and afterwards with *very dilute hydrochloric acid*, in order to remove the dressing and colour. Care must be taken that the liquors are not allowed to become concentrated, and fresh water should be added periodically to make up for the loss caused by evaporation. After the treatment with acid and alkali the fabric is boiled in clean water for an hour and afterwards well washed.

After washing, it should be dried and weighed in the weighing bottle. The loss in weight represents dressing and colouring matter. The amount of the dressing, etc., is then calculated to a percentage of the *original* weight of cloth taken.

If the whole of the colour be not removed by the foregoing treatment, the dried fabric should be treated with ether in the Soxhlet's tube, as described on page 493.

After the dressing and colour have been removed the dried cloth should be immersed in ammoniacal copper oxide solution for twenty minutes. This dissolves the cotton fibre. Water should then be added and the residue filtered off. This residue should be thoroughly washed, dried, and weighed. The weight found is the amount of *dry* wool in the mixed fabric, and to this should be added the amount of water natural to it, and this weight calculated to a percentage of the *original* cloth taken.

To determine the percentage of cotton present a second portion of the fabric is freed from dressing and colour, and treated as follows:—

The fabric should be boiled for two hours in a solution of caustic potash, 8°B. During the boiling operation, water should be added to make up for loss due to evaporation. The wool is dissolved out by this treatment. The cloth is then well washed with water, rinsed in dilute hydrochloric acid, washed again in water, and finally re-dried until the weight

is constant. To the weight of *dry cotton* the amount of natural moisture (8 per cent. of the natural cotton), should be added, and the amount of natural mineral matter (1 per cent.), and the total amount of *natural cotton* should then be calculated to a percentage of the *original* cloth operated upon. The amount of moisture natural to the cotton is deducted from the total moisture found.

The analysis will now read as follows:—

	PER CENT.
Natural Cotton, including moisture.....	
Moisture, less moisture due to cotton.....	
Dry Wool	
Dressing.....	

The moisture found in wool, as previously stated, is 15 to 18·25 per cent.; therefore about 18 per cent. should be added to the percentage of dry wool. This amount of moisture should be deducted from the total moisture found. If this 18 per cent. does not include all the moisture found in the fabric (except that which is due to cotton), the balance is excess moisture, due either to the dressing or to added water. The corrected analysis will then read:—

	PER CENT.
Natural Cotton, including moisture...	
Natural Wool, do. do. ...	
Dressing	
Excess Moisture	

DETECTION AND SEPARATION
OF COTTON AND LINEN.

The fabric, if white, should be treated with alcoholic fuchsine solution (1 per cent. strength). It is afterwards washed with clean water until the colour ceases to run, and then steeped in solution of ammonia for a few minutes. Linen is dyed a rose colour, whilst cotton remains uncoloured. (This test is reliable only if the fabric be free from starch. If starch has been used in the "finishing" process it may be removed by treating the cloth with a solution of malt, as described on page 47. The diastase in the malt renders the starch soluble, and it may then be removed by boiling in water).

Strong caustic potash solution imparts a very slight yellowish tint to cotton, whereas linen is dyed a deep yellow. This alkali may therefore be used as a test for detecting cotton in linen.

Where it is necessary to get out the proportion of cotton and linen in a fabric, the following method of procedure may be adopted:—The percentages of dressing and moisture, in a carefully weighed portion of the cloth, should be determined by the methods described on pages 491 and 492. The cloth is then placed in strong sulphuric acid (66° B) for two minutes, rinsed out well with water, and rubbed between the fingers. It is afterwards neutralised by soaking in a dilute solution of carbonate of sodium, and then in ammonia. The fabric is further well

washed in water and dried. Linen fibre is not destroyed by this treatment; cotton fibre is dissolved. The amount of linen found should be calculated to a percentage.

SEPARATION OF SILK AND COTTON.

The dressing and dye having been removed, as previously described, the fabric is treated with ammoniacal nickel oxide, which dissolves out the silk. A quantitative estimation may be made by getting out the percentage of moisture, dressing, and total fibre, as described on page 491 *et seq.*

Silk is dissolved by a strong boiling solution of chloride of zinc.

SEPARATION OF SILK AND WOOL.

These fibres may be estimated in a mixed fabric by boiling a weighed portion in hydrochloric acid. Silk is readily dissolved by this treatment; wool simply swells up.

CHAPTER XIII.

The Analysis of Sized Grey Cloth.

A MANUFACTURER very often requires to know the amount and general composition of the size contained in a piece of cotton cloth. This information may be required in order to match the cloth, or it may be required in order to determine the cause of some damage, such as the formation of mildew or iron stains. Where it is required to match the cloth, it is possible for the manufacturer to make an analysis sufficient for the purpose, providing he has the necessary facilities. But when damage has occurred it will not be advisable for him to attempt to solve the difficulty, even if he possesses the necessary qualifications. At the same time nothing will be lost by giving a full description of the processess involved in making a cloth analysis. With this object in view the writer intends to first describe the method of determining the percentages of cotton fibre and size in a sample of cloth, and the method of determining the *nature* of the

constituents of the size, and afterwards the method of determining the *proportions* of the various ingredients which may be found present.

1st.—QUALITATIVE ANALYSIS.

A portion of the cloth is steeped in cold distilled water for twelve hours. The liquid is afterwards filtered off, and examined as follows :—

(A) ACIDITY OR ALKALINITY.—These conditions should be tested for by means of litmus paper, as described on page 34.

(B) CHLORIDES AND SULPHATES.—The presence of chlorides and sulphates should be determined as follows :—

(1) CHLORIDES.—To a portion of the original solution a few drops of the nitric acid and nitrate of silver solution should be added. The formation of a white curdy precipitate indicates chlorides. This precipitate should be insoluble in strong nitric acid, but soluble in an excess of ammonia.

(2) SULPHATES.—To another portion of the original solution a few drops of hydrochloric acid and chloride of barium solution should be added. The formation of a heavy white precipitate indicates sulphates. If a heavy precipitate be obtained by the above test, the presence of Epsom salts or Glauber's salts is indicated; the probability being that it is Epsom salts.

(c) Salts of ZINC, CALCIUM, and MAGNESIUM, should be tested for as follows:—

(1) ZINC.—To a portion of the filtered solution a few drops of solution of ammonia, chloride of ammonium, and sulphide of ammonium, should be added. The formation of a white precipitate (sulphide of zinc) indicates the presence of zinc. Sometimes this precipitate is dark through the presence of traces of iron salts.

If zinc be present, another portion of the original solution is treated as follows:—

(2) CALCIUM AND MAGNESIUM.—Solutions of ammonia and chloride of ammonium should be added in excess. The excess of ammonia dissolves the zinc (which is first precipitated as hydrate of zinc), whilst the excess of chloride of ammonium prevents the precipitation of magnesium along with the calcium in the next test.

CALCIUM.—To the above prepared solution a solution of oxalate of ammonium, in slight excess, is added. Calcium, if present, is precipitated as oxalate of calcium. If a white precipitate be formed it is filtered off, and the filtered liquid tested for magnesium as follows:—

MAGNESIUM.—A solution of phosphate of ammonium should be added to the solution from the calcium precipitate. The immediate formation of white granular precipitate (magnesium ammonium phosphate), indicates magnesium.

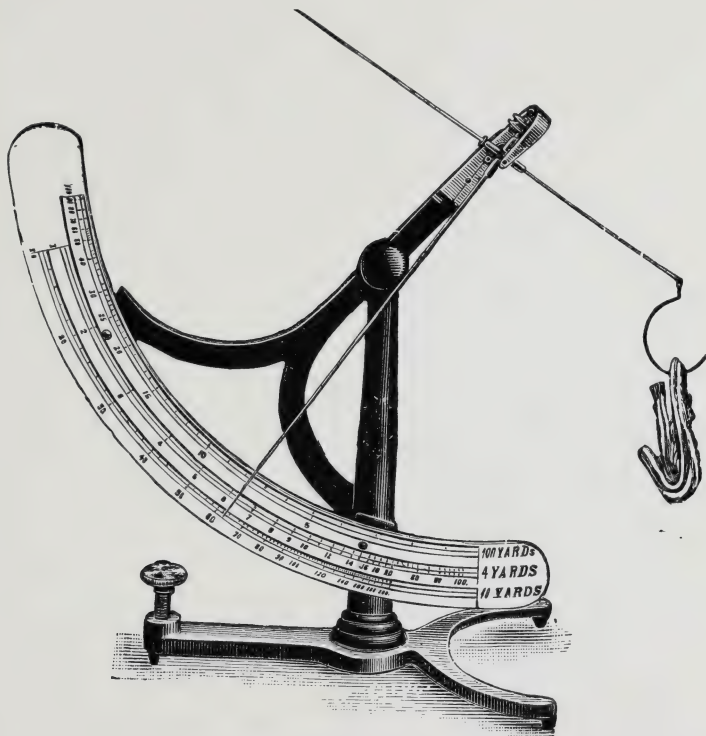
In all cases an excess of each reagent must be added in order to prevent a base being carried forward through incomplete precipitation. This may be easily avoided if the mixture be filtered and a little more of the reagent added. If no further precipitation takes place the whole of the base in question has been removed.

(D) DEXTRIN.—This substance may be present as an ingredient of the size, or it may be present on account of the use of wheaten flour of which it is a constituent. Dextrin is soluble in cold water, and it may be detected by means of iodine solution, as described on page 53.

(E) STARCH AND CHINA CLAY.—The residue on the filter paper, through which the original solution was filtered, will contain the starch and China clay, if present. A portion of this residue should be tested for starch with iodine solution, as described on page 36. Another portion of the residue should be examined under the microscope. Insoluble mineral matter such as clay will be at once detected, and very often a number of unbroken granules of starch will be found, showing what particular starch has been used in the size.

The foregoing tests will give a general indication of the composition of the size. It will then be necessary to determine the proportions of cotton fibre and size in the cloth, together with the percentage of mineral matter present. The simplest method

of determining the percentages of cotton fibre and size is carried out by means of the cloth quadrant which is shown below.



The Cloth Quadrant.

This most useful instrument is used as follows:— A piece of cloth exactly one-tenth of a yard square (a templet is sold with each quadrant which is exactly one-tenth of a yard square) is cut from the middle of the sample undergoing examination. A very sharp knife is used for this purpose, so that

the cloth may be cut perfectly clean. Any loose threads of warp and weft should be pulled out, passed through a hole made in the side of the cloth, and tied. The cloth is then put on the hook of the quadrant and the weight in pounds noted. The weight shown is the equivalent of a piece of cloth 100 yards long and one yard wide.

The cloth should then be chemically washed, and afterwards dried until it ceases to lose weight. It is then again weighed on the quadrant. The method of chemically washing is described in detail on page 491. The result of the second weighing gives the weight in pounds of pure *dry* cotton fibre. To this should be added eight per cent. for the moisture natural to cotton and one per cent. for the natural mineral matter removed by washing. After these additions have been made the weight is calculated to a percentage of the original cloth taken; the loss being size, and moisture due to the size.

The amount of weft present in the cloth may be obtained by the aid of the quadrant as follows:—The sample submitted, the actual width of which must be known, should be more than 18 inches wide in order that threads of weft exactly 18 inches long may be obtained from it.

A measure exactly 18 inches long is sold with the quadrant.

The cloth is straightened out and the measure laid upon it. A portion 18 inches wide is cut

by passing a sharp knife across the ends of the measure. This piece is then torn weft way to get a straight edge and afterwards weft threads are pulled out until 8 threads are obtained. This weft, a total of 4 yards, is hung on the hook of the quadrant which registers the "counts."

Another 8 threads should then be taken from the cloth, and after the "counts" have been ascertained, the whole 16 threads should be hung on the hook and the number shown on the quadrant multiplied by 2. These operations should be repeated on several portions of the cloth in order to get a fair average of the "counts" of weft in the cloth.

In all cases the "counts" as shown by the quadrant are slightly heavier than the actual "counts" used in the cloth. This is due to the interlacing of the weft with the warp. It will easily be seen that there will be more than 18 inches of yarn in the measured 18 inches of cloth. The exact determination of the counts of weft requires considerable experience. For one thing it is necessary to take into account the "reed" and "pick," because the increase in the number of threads per inch will increase the length of actual yarn in the measured cloth.

After obtaining the percentage of cotton with its natural moisture, the "counts" of weft, and the "reed" and "pick," a calculation will enable the manufacturer to determine the percentage and "counts" of twist. From these data he will be

able to calculate the percentage of size on the twist. An actual example is given below:—

FOR 100 YARDS, 36 INCHES WIDE, 64 × 64.

A Sample of cloth weighs 23·75 lbs.

The weft indicates 32's on the quadrant.

After washing out the size, drying, and
adding 9% for natural moisture and mineral
matter the cloth weighs 17·00 lbs.

Weight of size and moisture..... 6·75 lbs.

Total weight of yarn..... 17·00 lbs.

Total weight of size..... 6·75 lbs.

23·75 lbs.

The weight of weft is obtained by the following calculation:—

$$\frac{38 \times 64 \times 100}{840 \times 32} = 9\cdot05 \text{ lbs. weft.}$$

Total weight of yarn..... 17·00 lbs.

Total weight of weft 9·05 lbs.

Total weight of twist..... 7·95 lbs.

The “counts” of twist may be determined by the following calculation:—

$$\frac{36 \times 64 \times 106}{840 \times 7\cdot95} = 36\cdot5 \text{ “counts.”}$$

Total weight of twist 7·95 lbs.

Total weight of size..... 6·75 lbs.

Percentage of size on twist..... 85·0 per cent.

It will be seen that 2 inches have been added to the 36 inches for the weft, and 6 yards to the 100 yards for the twist. This is to allow for the increased length due to the interlacing of the yarns, or, as it is commonly termed, "the contraction in the cloth."

In actual sizing from such data allowance must be made for the loss of size occurring between tapeing and the woven cloth.

The "counts" of the twist and the percentage of size present on it may also be determined as follows: Twist threads, to the number of 210 each 18 inches in length (105 yards or $\frac{1}{8}$ of the length of a hank of yarn), are carefully pulled from the cloth, taking care to rub off as little size as possible. The weight in *grains* of these threads is ascertained by means of the balance, using the weighing tube described on page 22. The threads are then chemically washed, as described on page 491, and afterwards dried. After drying they are again weighed. The weight found is carefully noted, and to this weight 9 per cent. for natural moisture and mineral matter should be added. This gives the weight of actual twist present in the 210 threads taken, the balance being size. In order to ascertain the "counts" of twist, the corrected weight, in grains, of the 210 threads is multiplied by 8. This gives the weight for 840 yards = 1 hank. As there are 7,000 grains in 1 pound it will be necessary to divide

7,000 by the weight, in grains, of the hank. This will give the "counts."

After getting out the "counts" the percentage of size on the twist may be calculated. The weight of the 210 threads, after chemically washing and drying, etc., and correcting for natural moisture and ash, should be calculated to a percentage. Thus, if 50 per cent. of cotton and 50 per cent. of size be found, the twist would have 100 per cent. of size on it.

An example will make the foregoing description more clear:—

CALCULATION FOR "COUNTS" OF TWIST.

210 twist threads weighed 53·88 grains.

After chemically washing, and drying, and
correcting for natural moisture and ash,
they weighed..... 25·13 grains.

Balance = weight of size on 210 threads, 28·75 grains.

$25·13 \text{ grains} \times 8 = 201·04 = \text{weight of 1 hank, 840 yards.}$

This divided into 7,000 grains = 1 pound gives 34's "counts" of twist approximately.

CALCULATION FOR PERCENTAGE OF SIZE ON TWIST.

$25·13 \text{ grains} = 28·75 \text{ grains of size.}$

therefore $= \frac{28·75 \times 100}{25·13} = 114·4 \text{ per cent. of size on twist.}$

2nd.—QUANTITATIVE ANALYSIS.

When it is desired to make a full analysis of a sample of cloth, the following procedure should be adopted:—

ESTIMATION OF TOTAL SIZE.—A square piece of cloth, 10 or 15 grammes in weight, is cut, not torn, from the sample to be analysed in such a way as to get a fair average piece. Any loose threads should be pulled out carefully, folded up, put through a hole made at the side of the cloth, and tied. This piece should be most carefully weighed in the weighing tube and the weight noted. The cloth is then thoroughly washed for a few minutes in a stream of running water to remove as much size as possible. It is afterwards placed in a large enamelled pan or evaporating basin containing a 1 per cent. solution of caustic soda and boiled for an hour. After boiling, the cloth is taken out and thoroughly washed in clean running water. It is then boiled in a 1 per cent. solution of hydrochloric acid for one hour. Fresh water should be added at regular intervals to make up for loss by evaporation. If the acid liquor becomes concentrated it will tender the fibre.

After boiling in acid the cloth should be thoroughly washed in running water and finally boiled for an hour in clean water, after which it is washed again, then wrung out as dry as possible, and placed in the steam oven to dry.

When perfectly dry it should be pushed into the stoppered weighing tube, the stopper replaced, and the whole allowed to cool in the desiccator. It is then weighed, and after the tare of the

tube has been deducted the difference will be the amount of pure *dry* cotton fibre. The loss in weight represents the total size, with the moisture due to the size, and the moisture and mineral matter natural to the cotton.

To the amount of dry fibre 8 per cent. should be added for natural moisture and 1 per cent. for natural mineral matter. The percentage of *natural* cotton in the original cloth may then be calculated. This calculation does not quite give an accurate result as the washing processes remove a certain amount of oily and waxy matter from the cotton and also a certain amount of fibre, but it is near enough for all practical purposes.

The reader must remember that *in* every 100 parts of natural cotton 8 parts are moisture, so that 8 must be added to every 92 parts of *dried* cotton to find the amount of natural cotton. The following will explain the calculation more clearly:—

$$\frac{\text{Weight of dry fibre} \times 8}{92} = \begin{array}{l} \text{amount of natural moisture} \\ \text{to be added to dried fibre.} \end{array}$$

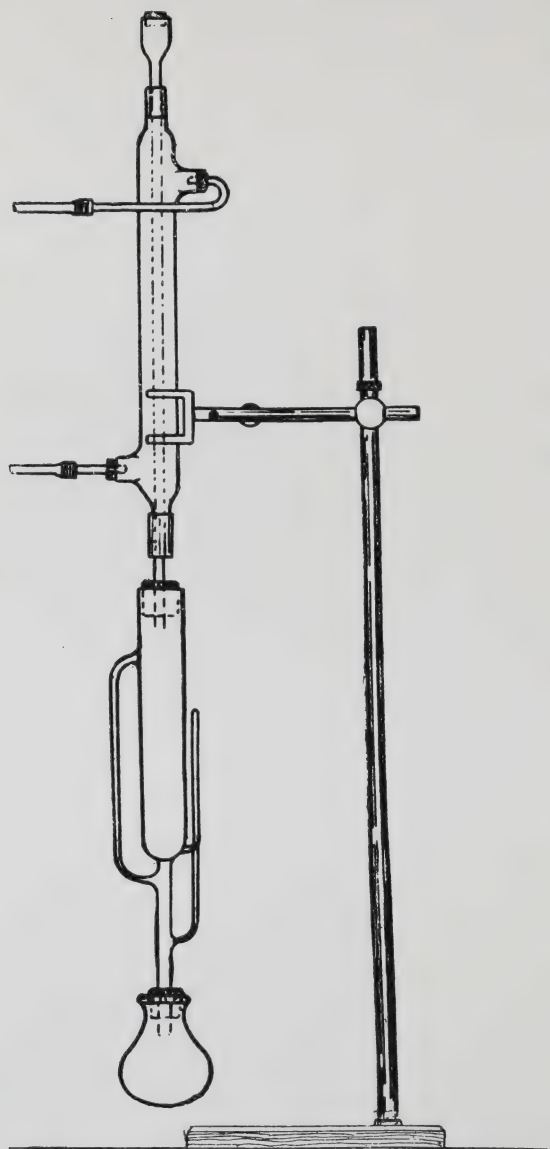
TOTAL MOISTURE.—About 10 grammes of the cloth should be carefully weighed in the weighing tube and dried in the steam oven until the weight is constant. The cloth should then be pushed into the tared stoppered glass tube whilst hot, and weighed when cold. From the total weight deduct the tare of the tube. The balance is the weight of the dry fabric. This weight, deducted from the original

weight of the cloth taken, gives the amount of loss which is due to moisture, and should be calculated to a percentage.

The above estimation should be made very carefully as the question of damage frequently turns upon the amount of moisture present in a sample of cotton cloth. Any moisture above 8 per cent. is expressed as excess moisture.

ESTIMATION OF FATTY AND WAXY MATTERS:— 10 to 15 grammes of the cloth should be carefully weighed, and the fat or wax extracted in the Soxhlet's tube by means of ether or petroleum spirit. An illustration of the Soxhlet's apparatus is shown on page 494. It consists of a Soxhlet's tube connected with a strong glass flask by means of a good cork. The upper portion of the tube is connected by means of a cork with an upright condenser. The sample of cloth is placed in the Soxhlet and sufficient ether poured into the flask. They are then fitted together and the condenser placed in position. The lower tube of the condenser is attached to the water supply by means of a piece of rubber tube. The upper tube is used for the overflow. The supporting stand should be sufficiently high to allow the flask to be placed in the bath containing water, which is heated by means of the Bunsen's flame.

The ether distils from the flask and passes in the form of vapour through the Soxhlet's tube into



Soxhlet's Fat Extraction Apparatus.

the condenser. From this condenser it drops back again upon the cloth in the Soxhlet's tube as a liquid. When the ether reaches a certain height in the tube it syphons over carrying the dissolved fat or wax with it.

This operation is repeated, and, as the distilled ether is continually dissolving fat or wax from the piece of cloth and passing back into the bottom flask, this will eventually become charged with all the fat or wax previously contained in the cloth. The apparatus is then disconnected and the solution of fat in ether is afterwards transferred to a *tared basin* which is heated on the water bath until the ether is driven off. It is then transferred to the drying oven, and dried until quite free from any trace of ether or water. After drying it is cooled, weighed, and the weight found calculated to a percentage of the cloth taken.

The fat may be examined as to its character, etc., and certain information as to its origin obtained by taking the melting point. Too much reliance must not be placed upon the indications given by the melting point as there are certain small quantities of impurities removed from the cotton itself by ether which affect this.

Great care must be exercised in evaporating ether, as this substance is very inflammable.

MINERAL MATTER.—If mineral matter has been found in the preliminary analysis, it will be necessary

to determine its amount and composition.

About 10 grammes of the cloth should be carefully weighed, the weight noted, and the cloth burnt in a weighed platinum or porcelain crucible. When the whole of the organic matter has been destroyed there will remain a white or grey ash, which should be carefully weighed and the weight calculated to a percentage. This will consist of the China clay and the other mineral substances present.

Before the percentage of China clay in the percentage of total ash can be determined, it will be necessary to ascertain the percentages of the other mineral substances which are not volatilised, such as the chlorides of magnesium, calcium, and sodium, and the sulphates of magnesium and sodium.

Chloride of magnesium will exist in the ash as oxide, and the percentage of this oxide must be deducted from the percentage of ash.

Chloride of calcium, chloride of sodium and the sulphates of magnesium and sodium will exist as such in the ash (but without their natural water), and after determining their percentages, these percentages should be deducted from the percentage of ash.

Cotton ash, to the amount of 1 per cent. of the cotton fibre found, should also be deducted from the total percentage of ash.

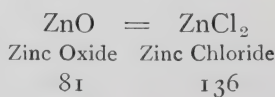
The percentage of ash then remaining after these deductions is *dry* China clay, and to this should be

added the 10 per cent. for water natural to ordinary China Clay. (N.B.—Practically the whole of the chloride of zinc will be removed by volatilisation during the incineration of the cloth.

DETERMINATION OF ZINC, MAGNESIUM, CALCIUM AND SODIUM SALTS.—10 to 15 grammes of the cloth should be carefully weighed, placed in a dry conical beaker and treated as follows:—About 250 c.c. of distilled water should be roughly measured, and 10 c.c. of strong hydrochloric acid added. From this mixture 200 c.c. are taken by means of a 100 c.c. pipette, and run into the beaker containing the cloth. The cloth should be pressed with a glass rod in order to allow the liquid to thoroughly saturate it. The glass rod should remain in the beaker until the liquid is filtered off. The beaker should be covered over with a watch glass and the cloth should be allowed to digest in the liquid for a few hours, with occasional stirring and pressing, after which it is filtered off. The cloth should then be wrung out over the filter paper. As soon as the whole of the solution has passed through the filter paper it should be well shaken up. 100 c.c. of the filtered solution should be drawn off by means of the pipette, and the zinc, calcium, magnesium, etc., determined as follows:—

The solution is first boiled with a few drops of nitric acid, and afterwards an excess of ammonia and chloride of ammonium should be added. Iron

(and occasionally alumina from the China clay) is precipitated if present. If a precipitate be formed it must be filtered off and washed. The washings should be collected in the vessel containing the filtrate. The precipitate is re-dissolved in hydrochloric acid, and re-precipitated as described above, in order to remove any trace of hydrate of zinc carried down with the iron and alumina precipitates. The filtrate and washings from the second operation should be added to the first filtrate. A solution of sulphide of ammonium should then be added in excess to the cooled filtrate from the iron, etc., and the whole set on one side for a few hours. The precipitate of sulphide of zinc is then filtered off through a filter paper, the ash of which is known. This precipitate should be well washed with a mixture of sulphide of ammonium and distilled water. The filtrate and the washings from the zinc precipitate are collected in a beaker and tested for calcium and magnesium as described later. The zinc precipitate is dried and transferred to a tared crucible, and ignited for some time. The filter paper is burnt on the lid of the crucible, ignited, cooled, treated with a drop of nitric acid, re-ignited, and weighed along with the crucible. The oxide of zinc, ZnO , formed by ignition, is weighed and calculated to chloride of zinc.

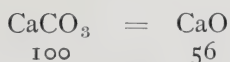


The amount of chloride of zinc found, multiplied by 2, gives the amount present in the cloth taken, and this should be calculated to a percentage.

CALCIUM.—A solution of oxalate of ammonium should be added in excess to the filtrate from the zinc. If no precipitate be formed on standing a few minutes calcium is absent. If present the solution must be boiled. It is better to avoid boiling if calcium be not shown in the cold solution, as this causes a precipitation of sulphur from the excess of sulphide of ammonium present.

The calcium precipitate should be filtered off and well washed with distilled water. The filtrate and washings should be reserved for the magnesium determination.

The precipitate of oxalate of calcium is dried, transferred to a weighed crucible, and gently ignited, thus forming carbonate of calcium. It is then moistened with a solution of pure carbonate of ammonium, evaporated to dryness, heated until no more fumes are evolved, and weighed as carbonate of calcium, CaCO_3 . This is calculated to oxide, CaO .



The amount of oxide multiplied by 2 gives the amount present in the cloth taken and this is calculated to a percentage.

The calcium may have existed in the cloth as chloride or as sulphate of calcium, or both, and this

must be ascertained when making up the results after getting out the percentage of sulphuric acid as (SO_3) and chlorine (Cl_2). Whichever salt is found it will be necessary to deduct the percentage from the total percentage of ash.

The filtrate and washings from the calcium precipitate should be evaporated down to about 30 c.c. The sulphur, which is precipitated by this treatment, is filtered out and well washed with boiling distilled water to remove every trace of the magnesium or sodium salts which may be present. After cooling the filtrate and washings, one-fourth of the volume of strong ammonia, and an excess of phosphate of ammonium should be added, in order to precipitate the magnesium. The whole should be set aside for some hours. Care should be taken not to touch the sides of the beaker with the stirring rod otherwise particles of the precipitate will adhere so tenaciously that they can be removed only with difficulty. The precipitate should be collected on a filter paper and thoroughly washed with a mixture of distilled water and ammonia. The filtrate and washings from the magnesium are mixed, and the amount of sodium salts, if present, determined as described later.

The magnesium precipitate is dried, and transferred to a weighed platinum crucible, the filter paper is burnt on the lid, and the ash is added to the contents of the crucible. The whole should then

be strongly ignited for some time, and weighed as pyrophosphate of magnesium ($\text{Mg}_2\text{P}_2\text{O}_7$). It sometimes happens that even after prolonged ignition the magnesium salt remains black. Should this be the case, it is, after cooling, moistened with strong nitric acid, carefully dried and re-ignited.

The pyrophosphate of magnesium is calculated to oxide (222 parts by weight of $\text{Mg}_2\text{P}_2\text{O}_7 = 80$ parts by weight of MgO).

$$\begin{array}{ccc} \text{Mg}_2\text{P}_2\text{O}_7 & = & 2\text{MgO} \\ 222 & & 80 \end{array}$$

The amount of oxide found, multiplied by 2, gives the amount of oxide present in the cloth. This is calculated to a percentage, and the percentage should be deducted from the percentage of total ash. From the percentage of oxide of magnesium, the percentage of chloride of magnesium may be calculated. Every 40 parts of oxide represent 95 parts of chloride.

$$\begin{array}{ccc} \text{MgO} & & \text{MgCl}_2 \\ 24 + 16 & = & 24 + 71 \\ \underbrace{\hspace{1.5cm}} & & \underbrace{\hspace{1.5cm}} \\ 40 & & 95 \end{array}$$

If sulphates have been found in the preliminary tests, the magnesium may be present both in the form of sulphate of magnesium and chloride of magnesium. In this case the calculation *to total* chloride will have to be omitted, and the deduction from the percentage of ash corrected after the

amount of magnesium existing as sulphate has been ascertained. The correction will be as follows:—

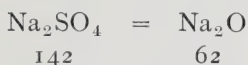
The whole of the percentage of sulphate of magnesium must be deducted from the percentage of ash, and the percentage of chloride of magnesium then calculated back to oxide, and this percentage of oxide also deducted from the ash.

The filtrate and washings from the magnesium precipitate should be evaporated to a small bulk and the sodium salts determined as follows:—

DETERMINATION OF SODIUM SALTS AS SULPHATES,—The sodium may have existed in the cloth as chloride of sodium or sulphate of sodium, or both. An excess of chloride of barium solution should be added to the solution from the magnesium precipitate, in order to precipitate phosphoric acid.

The mixture is then filtered and the precipitate washed with distilled water. The filtrate and washings are collected in a beaker. An excess of carbonate of ammonium is added to the solution to precipitate the excess of barium. The precipitate is filtered off and well washed with distilled water. The filtrate and washings are transferred to a tared porcelain basin, and evaporated to dryness on the water bath. The residue is heated to drive off all salts of ammonium, cooled, and an excess of strong sulphuric acid added. The basin should be carefully heated until acid fumes cease to come off

and afterwards strongly ignited. A piece of carbonate of ammonium should then be placed in the basin, which is re-heated. The residue is sulphate of sodium, Na_2SO_4 . This should be cooled and weighed, and the weight of the basin be deducted. The amount of sulphate of sodium found should be multiplied by 2, and calculated to oxide of sodium, Na_2O .



This is further calculated to a percentage of the cloth taken.

ESTIMATION OF SULPHURIC ACID AND CHLORINE.—The proportion of sodium existing as chloride and as sulphate is determined after ascertaining the amount of combined chlorine and sulphuric acid. For this purpose another portion of the cloth should be steeped for several hours in dilute alcohol, specific gravity 0.92, under the same conditions as given on page 497.

Ten to fifteen grammes of cloth should be carefully weighed and steeped in exactly 250 c.c. of the dilute alcohol for five or six hours. It is afterwards filtered and treated as follows:—

(1) SULPHURIC ACID.—100 c.c. of the filtered solution should be placed in a suitable beaker, the alcohol boiled off, and a few drops of hydrochloric acid and an excess of solution of chloride of barium

added in order to precipitate sulphuric acid, if present, as sulphate of barium.

The precipitate should be collected on a filter paper. It is then well washed, dried, and finally transferred to a tared porcelain crucible. The filter paper should be burnt in the Bunsen's flame as follows:—It is first rolled up into as small a compass as possible, and then wrapped round with a platinum wire so as to form a cage. This ash is added to the contents of the crucible, and the whole ignited for some time. The crucible is then allowed to cool, and afterwards a drop of sulphuric acid (to convert any sulphide of barium, formed by reduction, into sulphate) is added. The crucible is again carefully ignited, cooled, and weighed.

The sulphate of barium BaSO_4 , is calculated to SO_3 , each 232·8 parts by weight of $\text{BaSO}_4 = 80$ parts by weight of SO_3 .

$$\frac{\text{BaSO}_4}{232\cdot8} = \frac{\text{SO}_3}{80}$$

As 100 c.c. of the 250 c.c. of original solution have been used, the weight found will be two-fifths of the weight of SO_3 on the cloth. The amount actually in the cloth should be calculated, and then further calculated to a percentage.

The SO_3 found by this treatment may have existed as magnesium or sodium sulphate, or both, Calcium sulphate is not soluble in dilute alcohol, so that this salt cannot be present.

(2) CHLORINE.—100 c.c. of the solution in dilute alcohol should be placed in a suitable beaker, the alcohol boiled off, and a few drops of nitric acid and an excess of nitrate of silver added. The chlorine is precipitated as chloride of silver. The supernatant liquid is poured off through a filter paper. The chloride of silver is washed once or twice with hot water, and the washings poured over the filter paper. The precipitate is then transferred to the filter paper and the washing continued. The precipitate is afterwards dried. After drying, as much of the precipitate as possible is removed from the paper to the crucible. The filter paper is then burnt on the inverted lid of the crucible. It is afterwards moistened with a drop of nitric acid, warmed, and a drop of hydrochloric acid added. It is then evaporated to dryness, after which the lid is replaced on the crucible, and the whole ignited until the edges of the mass of chloride of silver begin to fuse. The crucible and contents are allowed to cool and then weighed. Every 143·5 parts of chloride of silver contain 35·5 parts of chlorine.

$$\begin{array}{rcl} \text{AgCl} & = & \text{Cl} \\ 143\cdot5 & & 35\cdot5 \end{array}$$

The amount of chlorine found is two-fifths of the actual chlorine present as chlorides in the weight of cloth taken. The actual weight is calculated, and then further calculated to a percentage.

In the absence of sulphate of magnesium, sulphate of sodium, sulphate of calcium, chloride of sodium, and chloride of calcium, the problem of uniting the bases found with the respective acid radicals is an easy one. Thus the whole of the zinc will exist as chloride of zinc, and the whole of the magnesium will exist as chloride of magnesium. From the percentage of oxide of zinc found by analysis the weight of chloride of zinc may be readily calculated, and from the percentage of oxide of magnesium found by calculation, the chloride of magnesium may be calculated.

The presence of other chlorides and sulphates increase the difficulty of the problem. Considerable experience is then required in order to rationally combine the different bases with their acid radicals.

The following may be taken as a general method of procedure:—Where zinc, magnesium, chlorine, and sulphuric acid are found, with only a trace of sodium and calcium—

(a) The whole of the zinc should be combined with sufficient chlorine to saturate it, forming chloride of zinc.

(b) The sulphuric acid radical, SO_3 , will combine with sufficient oxide of magnesium to form sulphate of magnesium.



(c) The balance of oxide of magnesium will combine with sufficient chlorine to saturate the whole of it, forming chloride of magnesium.

If calcium has been found, and there is more chlorine than can be taken up by the zinc and magnesium, after the SO_3 has been saturated, the calcium will exist as chloride of calcium.

To determine whether the whole of the calcium in the cloth exists as chloride, the following method is useful:—A measured portion of the solution, obtained by digesting a weighed portion of the cloth in dilute alcohol, is operated upon. This is tested for calcium in the usual way. If calcium be found it will have existed as chloride of calcium, CaCl_2 , and the operation must be conducted so as to allow a quantitative estimation to be made. The amount of chloride of calcium present should be calculated to a percentage of the cloth originally taken. From this percentage of chloride should be calculated its equivalent of CaO , and this must be deducted from the total amount of oxide of calcium found previously. The balance of oxide of calcium will exist as sulphate, and will of course saturate its equivalent of SO_3



If sodium has been found it may exist either as sulphate or chloride, or both.

If, after combining the zinc, magnesium, and calcium with the chlorine and sulphuric acid, there still remains an excess of uncombined chlorine and sulphuric acid, then both chloride and sulphate of sodium are present, but if only chlorine be left uncombined, then the salt is chloride of sodium; or if only sulphuric acid be left uncombined, then the salt is sulphate of sodium. Every 62 parts of oxide of sodium by weight will require 71 of chlorine, producing 117 parts of chloride of sodium.



Every 62 parts of oxide of sodium will require 80 parts of SO_3 producing 142 parts of Na_2SO_4

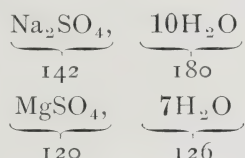


The following are the deductions which should be made from the total percentage of ash found in the cloth:—

- 1.—The percentage of ash natural to cotton fibre
= 1 per cent. of cotton found.
- 2.—The percentage of oxide of magnesium which
exists as chloride.
- 3.—The percentage of sulphate of magnesium.
- 4.—The percentage of chloride of calcium.
- 5.—The percentage of sulphate of calcium.
- 6.—The percentage of chloride and sulphate of
sodium.

After these deductions have been made 10 per cent. should be added to the balance of ash remaining for the moisture natural to China clay.

Whenever sulphate of sodium or sulphate of magnesium is found allowance must be made for the water of crystallization contained in them. If the analysis has been made with the view of matching the cloth at least twice the quantity of each of these substances must be used to allow for the water of crystallization, viz.:—



The amount of zinc left in the ash after ignition may be neglected in the above deductions.

The authors have known of cases where the chloride of zinc has been determined from the ash instead of directly from the cloth. Such methods are not accurate as a certain amount of the chloride of zinc exists on the cloth as oxychloride of zinc. When the cloth is ignited, a portion of this is converted into metallic zinc, which is volatilised at a bright red heat, and is thus lost. Chloride of zinc also volatilises at a bright red heat, so that any analysis of the ash for this substance must be inaccurate.

As the responsibility for mildewed cloth frequently turns upon the amount of chloride of zinc

present in the cloth too much care cannot be exercised in ascertaining the exact quantity of this substance.

There now remains to be calculated the amount of starchy matter, dextrin, etc. This is obtained by difference. The whole of the ingredients having been calculated to percentages, we have :—

COTTON—	PER CENT.
Fibre.....	
Natural Moisture.....	
Natural Ash.....	
SIZE—	
Moisture	
Fatty Matter	
China Clay with natural moisture ...	
Chloride of Zinc ..	
Chloride of Magnesium	
Sulphate of Magnesium	
Chloride of Calcium	
Sulphate of Calcium	
Sulphate and Chloride of Sodium ...	
Starchy Matter by difference ...	
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The starchy matter in the analysis includes all organic matter present in flour, such as gluten, dextrin, albumen, etc. It is seldom necessary to isolate the starch and determine its exact percentage, as a cloth analysis, such as described here, is generally made for the purpose of fixing liability where something has gone wrong with the cloth, such as the development of mildew, and for this purpose

the organic matter in flour may be estimated by difference.

The following analyses show the composition of various kinds of cloth submitted to the writer:—

ANALYSES OF VARIOUS SAMPLES OF
SIZED GREY CLOTH.

	Percentages.					
	1	2	3	4	5	6
Cloth :—						
Dry Cotton Fibre and Ash	55·80	62·92	62·95	74·89	79·07	83·96
Moisture	4·80	54·7	5·47	6·51	6·32	7·30
Size :—						
Moisture	3·96	4·02	5·28	2·69	2·49	0·71
Starchy Matter	15·42	8·12	9·09	3·88	9·60	7·52
Fatty Matter	4·90	2·10	3·12	2·14	1·94	0·43
China Clay, natural	12·54	15·63	10·93	8·63	0·21	...
Chloride of Zinc	0·94	0·48	0·46	0·13	0·03	...
Chloride of Magnesium	1·64	1·26	2·70	1·13	0·34	0·08
	100·00	100·00	100·00	100·00	100·00	100·00
Total Cloth.....	60·60	68·39	68·42	81·40	85·39	91·26
Total Size	39·40	31·61	31·58	18·60	14·61	8·74
	100·00	100·00	100·00	100·00	100·00	100·00
Excess Moisture	0·76	1·16	2·75	1·20	0·81	0·01
Percentage of Zinc to Starchy Matter...	6·09	5·91	5·06	3·30	0·31	...

The above samples, except No. 1, were mildewed, and they will be referred to again in the next chapter. No. 1 sample does not contain the amount of zinc it should contain, although it was free from mildew when submitted to the writer.

CHAPTER XIV.

*Damage to which Sized Cloth is liable.
Mildew and Iron-stains.*

MANUFACTURERS in Lancashire have sustained enormous losses from time to time through the development of mildew and iron-stains in sized grey cloth. The origin of these forms of damage have been carefully investigated, and the information at the disposal of the manufacturer to-day is sufficient to prevent anything like the serious losses of thirty or forty years ago. Still mildew and iron-stains are yet great sources of trouble and annoyance.

MILDEW.

Mildew is the name given to the growth of a class of low vegetable life known as fungi, of which there are about two thousand varieties known to the botanist, and these vary in size and colour very considerably.

The manufacturer is more particularly interested in the growths of fungi which attack "sized" cotton cloth. They are large in number, and characterised by different colours. Their origin and distribution in a bale of cotton cloth is dependent upon the cause of their development.

BLACK MILDEW.—This fungus is generally the one known botanically as *Tilletia*, and is more often found on the twist and cloth, either in the weaving shed or warehouse, than on cloth returned from abroad. Its presence is generally due to the absence of the proper proportion of chloride of zinc in the size, or through the "taper" having run his yarns too damp. This form of mildew will make its appearance under the latter conditions, even where there is sufficient chloride of zinc to protect the cloth under ordinary circumstances.

GREEN MILDEW.—This form of mildew is either produced by the development of *Aspergillus glaucus* or *Penicillium glaucum*. Like black mildew it is often found in a weaving shed, due to the causes mentioned under black mildew.

YELLOW MILDEW.—Mildew of this colour is very often found upon the cloth, usually spotted over the piece in patches varying in size from that of a pin-head to a three-penny piece. It is generally produced from the yellow conceptacle of *Aspergillus glaucus*, and will develop with less air than the green *conidia* of the same species.

PURPLE MILDEW.—This form of mildew is frequently found by the writer in samples of flour paste which have been left exposed in the laboratory. It has the appearance as though the wet flour paste had been marked with a purple copying-ink pencil. Purple mildew does not penetrate below the surface of the paste. It is usual to find a development of red, green, or yellow mildew beneath the purple. W. Thompson, in his book on Sizing (1879), calls particular attention to this form of mildew. It is curious that in Manchester purple mildew almost invariably makes its appearance on samples of flour paste left about in the laboratory.

PINK MILDEW.—This form of mildew is not often found on "sized" cloth, as it does not develop so quickly as some other varieties. The finest crop ever seen by the writer was on the inside of half a cocoa-nut which had been left in a damp cupboard. The growth on the cocoa-nut was most luxuriant, and for months after it had been removed substances liable to mildew, such as bread, etc., developed pink mildew when placed in the cupboard. Bread had been stored previously in the cupboard but pink mildew had never developed upon it until after the cocoa-nut had been placed there. Like the purple form of mildew pink mildew is generally found on the surface only of flour or starch paste.

BRICK-RED MILDEW.—This form of mildew is fairly common in “sized” cloth. It is very often mistaken for iron-stains. This is due to placing too much reliance upon the usual test for iron, viz. :—The action of dilute hydrochloric acid and ferrocyanide of potassium. This test is fully described in the section on iron-stains. There is always sufficient iron in any piece of “sized” grey cloth, iron stained or not, to produce the blue colour unless the test is made very carefully. The hydrochloric acid must be used very dilute, otherwise it will decompose a portion of the ferrocyanide of potassium and produce the blue colouration.

BROWN MILDEW.—This form of mildew is very often found on mildewed cloth. It belongs to the species *Puccinia*.

TESTS FOR MILDEW.—As a rule the appearance and smell of a sample of damaged cloth is sufficient to determine whether the stain is due to mildew. Sometimes, however, the characteristic smell of mildew is absent entirely. This is probably due to the cloth having been exposed before it has reached the analyst.

It is too often decided that a stain is not mildew because the spores and filaments of the fungus cannot be seen when the fibres are examined under the microscope. As a matter of fact it rarely happens that any spores or filaments can be recognised on the yarns; the filaments of

cotton preventing their appearance being readily perceived. Too much reliance must not be placed, therefore, if positive proofs are not obtained when the stain is examined under the microscope. Very often in such a case the stain, if it be red or reddish brown, is wrongly put down to iron-stain.

In most cases where mildew is present the particular form may be cultivated. Care must be exercised to keep out the spores of other species.

The following tests are useful where there is any doubt in regard to a particular stain:—

(1) Treat the stained cloth with peroxide of hydrogen. Mildew will often bleach out; iron-stains are not affected.

(2) Treat the cloth with a filtered solution of chlorinated lime. Mildew will bleach out; iron-stains are not affected.

(3) Boil a portion of the cloth in a solution of caustic soda. The stains almost invariably become tinted purple or reddish purple by this treatment, whatever may have been the original colour.

(4) Compare the ash formed by burning a piece of cloth containing the stain with the ash obtained from a piece of the same cloth cut from an unstained portion. If the stain be due to iron there will be a marked difference in the colour of the two samples of ash. The portion containing the stain will be of a reddish yellow whilst the other ash will

be white or greyish white. This matter is further dealt with under iron-stains.

If the above test is made with cloth which is very "heavily" sized, it will be necessary to remove as much of the size as possible by washing the cloth in water, or treating with a solution of malt, as described on page 47, and drying previous to igniting it in the crucible. Iron-stains cannot be removed by such treatment, but mildew, especially if the fungus has attacked the starch only, may be almost entirely removed along with the starch. If the cotton itself has been attacked washing will not remove the stain.

LIABILITY FOR MILDEW.

The question of liability where cloth has mildewed has frequently to be determined. There can be no question that the manufacturer is responsible if the cloth does not contain sufficient chloride of zinc, or if the yarns have been "taped" too damp. At the same time there are many cases where the manufacturer is held responsible and yet he has taken every reasonable precaution to prevent damage:—For instance he is liable if he has used weft which has become slightly mildewed through the spinner "over-damping" the yarn, and which may not show signs of mildew at the time. It is almost impossible for him to place the blame on the

right shoulders after the damage has been done. This matter was fully discussed on page 471.

Then again there seems to be an unreasonable responsibility placed upon the manufacturer by the merchant who may make a claim for damage for mildew on cloth which has been stored for long periods. During times of bad trade it is no uncommon thing for claims to be made on cloth which has been stored from 12 month's to 2 years. The manufacturer has no control over the storage nor even over the packing of the cloth. The goods remain in the original bales until sold and if they are found to be damaged by mildew when opened a claim is put in. This is not fair to the manufacturer when cloth is shipped to hot countries like India and China. There should be a reasonable time-limit placed upon the merchant's right of claim.

The responsibility for damage from mildew may very often be settled by making an analysis of the cloth in order to determine the proportions of actual chloride of zinc to the starchy matter present in the "size." Experience has shown that 8 parts of chloride of zinc to 100 of starchy substances are sufficient to preserve cloth from mildew, *providing it is not subjected to unreasonable treatment*, either by the manufacturer, or by those people who handle it after it has left the manufacturer.

Unfortunately for manufacturers it is customary for most analysts who have *no practical experience* of

“sizing” and weaving to invariably place the blame for the development of mildew on cloth to the use of an excessive quantity of chloride of magnesium in the “size.” As a matter of fact manufacturers who are accustomed to make “heavy” sized goods rarely use excessive quantities of chloride of magnesium. There are many reasons for this. In the first place a well balanced “mixing” for “heavy” sizing does not require an excessive amount of chloride of magnesium, because the object of every manufacturer, who knows his business in “heavy” sizing, is to get the desired weight with the cheapest ingredient, viz:—China clay. On this account the smallest proportion of flour, and the largest proportion of China clay that can be got to adhere to the twist, is used. Flour or starch produces a harsh yarn whilst China clay has a tendency to soften it. Therefore, if a small proportion of flour be used much smaller proportions of the softening ingredients, such as tallow and chloride of magnesium, may also be used. On the other hand, if a large proportion of flour be used the yarns would be harsh, and it would be necessary to use a very much larger proportion of chloride of magnesium and tallow to soften them. As tallow is the most expensive ingredient employed in sizing the “mixing” would be a costly one.

It must be remembered that there is a limit to the use of chloride of magnesium as a “softener”

beyond which the manufacturer may not go without suffering damage. It has been tried over and over again to substitute chloride of magnesium for tallow, but there has always been one result when the limit has been passed, viz.:—*iron-stains* have developed in the weaving shed. This matter is more fully described under iron-stains.

The authors are strongly of opinion that very few cases of mildew are really traceable to the use of chloride of magnesium where chloride of zinc has been used in proper proportions.

Practical experience has shown that where an attempt has been made to use an excessive amount of this substance, *at the expense of the tallow*, it has soon been given up. This is accounted for in several ways. In the first place, because of the trouble and loss sustained through iron-stains developing in the weaving shed, and secondly, because an excessive quantity of chloride of magnesium would make the size and the yarns so damp that it would give rise to the condition known as “choving.” That is, the damp size would rub off as it passed through the healds, thus causing the eyes of the healds to become made up.

In spite of the fact that chloride of magnesium is rarely used in excessive quantities, it is painful to see experts commonly reporting that this ingredient is the cause of mildew in cloth which has been sent to them for analysis. The authors have come across

several cases recently which have been submitted to analysts who have reported that, "whilst finding the proportion of chloride of zinc to be sufficient to preserve the cloth from mildew, the proportion of chloride of magnesium has caused the cloth to absorb moisture to such an extent as to cause mildew." In several cases the cloth has been submitted to the writer, who has found practically the same proportions of the chlorides of zinc and magnesium as found by the other analysts. But, instead of the proportion of chloride of magnesium being excessive, it was present in the minimum amount which could be used for the class of sizing. In each case the analyst was bold enough, in his innocence, to tell the manufacturer to reduce the amount of chloride of magnesium in his "mixing" by one half. The manufacturer knew perfectly well that such a reduction was not possible in practice, and he has laughed at the folly of "expert advice." Two cases which have occurred recently where this advice was given will be described in detail.

In the first case the manufacturer knew that the damage had been caused at his own mill through storing the cloth against a very damp wall before it was sent to Manchester. He thought that conflicting "expert" evidence might help him to avoid any claim for the damage altogether, or induce the shipper to meet him in the claim for damages.

In the second case the manufacturer had sold "heavy" sized shirtings to a Manchester merchant, and after the goods had been in India about 18 months some of the pieces were found to be covered with mildew. One portion of the damaged cloth was sent to a firm of analysts by the merchants, whilst another portion was sent by the manufacturer to the writer.

The writer reported that the mildew was due to moisture, and that the moisture must have come in contact with the goods after they had left the manufacturer. He based his report, in the first place, upon the fact that the cloth contained sufficient chloride of zinc to prevent the development of mildew unless it had been unfairly treated. In the second place because the cloth contained a very small proportion of chloride of magnesium and flour, with a very large proportion of China clay. If the moisture had come in contact with the cloth before it left the manufacturer's hands mildew would have shown before the cloth had been shipped, or, if it had been caused, as is very often the case, through the taper running the yarns damp, it would have shown on the weaver's beam in the weaving shed. As a matter of fact it was not found until the cloth had been in India for the time stated, and then on a few pieces only. The manufacturer was in the habit of steeping large quantities of flour with chloride of zinc in the proportion of four gallons of

zinc to each sack of flour. If he had omitted to put in the right quantity of zinc, or if the damage had been due to an excessive quantity of chloride of magnesium, many thousands of pieces would have been damaged, instead of a few dozen pieces only. In this case the manufacturer was also informed that he would have to reduce the chloride of magnesium by one half if he was desirous of preventing a re-occurrence of the damage. Had this advice been followed it would have been impossible to successfully weave the yarn.

The most curious part about the report was that the analysis coincided with the writer's analysis so far as the proportions of chloride of zinc and of chloride of magnesium were concerned, but a considerable difference was shown in the proportion of total cotton fibre and size. This difference was still more marked when the size came to be calculated to a percentage on the twist, instead of upon the total cloth. In the writer's report it was shown that there was 125 per cent. of size on the twist, whereas in the report submitted by the other analyst the amount of size on the twist, on calculation, was 190 per cent. As a matter of fact the twist had been sized 140 per cent. only, and there had been the usual loss between tapeing and weaving. It is a well-known fact amongst all sizers that it is easier to produce "light" beams in "heavy" sizing, than to produce beams heavier than that for which the

“mixing” is intended. It was quite impossible for the twist to be sized to the extent of 190 per cent. with a 140 per cent. “mixing.” The manufacturer’s books proved that 140 per cent. was the amount of size actually put on the twist.

It was many months after the analysis had been made that the writer learnt the true cause of the mildew. One day his client admitted that he had always known its origin. He had been experimenting by sending his cloth to Manchester by road instead of by rail, and on one occasion the cloth had been caught in an unexpected shower of rain. The carter had not sufficient covering to protect the cloth, and this accounted for it receiving moisture after it had left the hands of the manufacturer. A great many cases of mildew owe their origin to cloth coming in contact with rain. The authors have often noticed how carelessly grey cloth is handled in Manchester. It is a common sight to see cloth being carried from luries into the warehouses on wet days without any protective covering. The rain falls upon the cloth, which is afterwards packed in a damp state into bales, and then shipped to India or China. There need be little cause for surprise that when the bales are opened the goods are found to be mildewed. Until cloth receives more reasonable treatment at the hands of shippers mildew will always be a source of loss and dispute,

especially in cases where the manufacturer has been using the *minimum safe* quantity of chloride of zinc.

Cases are not unknown where mildew has formed on "pure" sized grey cloth through being packed in damp card-board boxes. The flour paste used in making the boxes had not been thoroughly dry before the cloth had been put into them. The result was that the paste first mildewed, and afterwards the growth extended to the cloth.

It is often a very difficult matter to prove who is responsible for the damage due to the formation of mildew on cloth which has been shipped abroad. As a rule, however, a careful analysis of a sample of the cloth, and an examination of a bale of the mildewed goods, *together with a practical knowledge of sizing*, will give an expert all the information necessary to locate the source of the damage.

It will probably be interesting and instructive to the reader to have a few instances of mildew, with the cause of the damage, described.

In one case a manufacturer sent for analysis some fine dhooties, made from Egyptian yarns. These goods, which were supposed to be "pure" sized, were badly stained with mildew, but the fungus had attacked the starchy matter of the size only leaving the cotton fibre stained but undamaged.

An analysis of the cloth gave the following result:—

Cloth:—		PER CENT.
Cotton Fibre and Natural Ash	79'07	
Natural Moisture	6'32	
Size:—		
Moisture	2'49	
Starchy Matter	9'607	
Fatty Matter	1'935	
Mineral Matter in Size.....	578	
		<hr/>
		100'000
		<hr/>
Total Cloth	85'39	
Total Size	14'61	
		<hr/>
		100'00
		<hr/>
Excess Moisture.....	0'81	
		<hr/>
Mineral Matter:—		
China Clay	0'20	
Chloride of Magnesium	0'342	
Chloride of Zinc	0'036	
		<hr/>
		0'578
		<hr/>

This cloth should not have contained China clay or chloride of magnesium, and the manufacturer wrote to say that he never used these ingredients for these goods. An investigation at the mill showed how they had got into the size, and at the same time explained the cause of the damage.

It was the practice to make “pure mixings” in a beck which had been used previously for “mixings” of a “heavier” sort. The size mixer was in the habit of running off as much of the old size as possible, but he rarely took the trouble to clear out the beck entirely. The result was that a fair quantity of size from a “mixing” containing China

clay and chloride of magnesium was occasionally left in the beck and a "pure mixing" made on the top of it.

This accounted for the presence of chloride of magnesium and China clay in the goods which had mildewed. A very small quantity of chloride of magnesium is liable to produce mildew in "*pure*" sized cloth on account of the moisture it absorbs. It is not customary to use preservatives of any description in these goods. In the case mentioned above there was a small quantity of chloride of zinc present, but it was not sufficient to preserve the goods from mildew in the presence of chloride of magnesium.

Manufacturers who make a variety of "sorts" cannot be too careful in insisting that all "pure" mixings are made in clean becks. It is a well-known fact that "pure" sized goods are more liable to mildew than "heavy" sized goods if they come in contact with even a small amount of moisture. The reason is, of course, that "pure" sized goods rarely contain antiseptics of any description, whereas "heavy" sized goods usually contain sufficient antiseptic substances to prevent the formation of mildew.

It is not a matter of much concern if mildew forms on cloth which is intended to be bleached, unless the cotton fibre is attacked, because the mildew is easily washed out in the bleaching operations. But if the goods have to be sold in the grey state it is a very serious matter.

Mildew is frequently caused in “medium” and “heavy” sized goods on account of the size mixer omitting to put the full quantity of chloride of zinc into the mixing. Such an instance came under the writer’s notice a few years ago.

The manufacturers in this case sent the writer samples of “heavy” sized cloth which were badly mildewed, together with samples of a similar cloth which they were then making, and which were supposed to be sized in a similar manner and with a similar “mixing” to the goods which had mildewed abroad. An analysis of both samples was made with the following results:—

	Percentages.	
	Mildewed.	Free from Mildew.
Cotton and Natural Moisture	68·39	68·47
Size :—		
Moisture	4·02	3·84
Starchy Matter	8·12	8·01
Fatty Matter	2·10	2·21
Mineral Matter	17·37	17·47
	100·00	100·00
Excess Moisture	1·16	0·98
Mineral Matter consists of:—		
China Clay.....	15·63	14·96
Chloride of Magnesium	1·26	1·57
Chloride of Zinc	0·48	0·94
	17·37	17·47
Chloride of Zinc to Starch.....	5·91	11·73

From the analysis it will be seen that the cloths were practically the same, excepting that the mildewed cloth contained only half the percentage of chloride of zinc contained in that which was free from mildew.

There was no doubt at all in this case. The size mixer had forgotten to put in a portion of the chloride of zinc. This particular firm was in the habit of steeping the flour with a portion of the chloride of zinc only, afterwards adding the remainder to each "mixing" as it was completed. This is a very dangerous practice as it is always possible for the size mixer to forget to add the second portion. If the whole of the chloride of zinc had been mixed with the flour as advised by the authors, and if the quantities were invariably checked by a responsible man at the time, it would have been impossible to make a mistake of this kind.

It is not always the fault of the size mixer that too little chloride of zinc is present in the cloth. Instances are not unknown where the right number of gallons have been used, but the zinc has been adulterated to such an extent that mildew has occurred. It is always difficult to place the responsibility for mildew in such cases, as manufacturers rarely keep samples of any of the ingredients they have used. The only way to avoid such risks is to have every cask of zinc tested before it is used, if only by means of the hydrometer.

A curious case of mildew came under the writer's notice some few years ago. A piece of grey cloth having an orange border on one selvedge and a red border on the other, was sent to his laboratory with a note calling attention to the orange border, which was slightly discoloured in places. The discolouration was due to the presence of little yellow spots in the orange coloured yarns. The orange dye was chrome orange (oxychromate of lead). The first thing to suggest itself was that some kind of acid had come in contact with the dye, and reduced the oxychromate of lead to the yellow chromate.

A further examination of the body of the cloth showed minute traces of yellow mildew, only noticeable after most searching examination, and which would probably never have been seen had the orange border not been discoloured.

The yellow stains in the orange coloured yarns were not due to the colour of the yellow mildew, but to the reduction of the orange oxychromate of lead to yellow chromate by the action of the acids produced in the development of the mildew.

Experiments were made which proved that slightly sour or mildewed flour would discharge the orange dye and produce a yellow. Orange chrome dye, either for cloth sold in the grey, or for bleaching, has many objections. This matter is further discussed under bleaching.

Another interesting case which might be mentioned was one in which the writer was called in as arbitrator. The damaged cloth was a "heavy" "sized" coloured bordered dhootie, the coloured yarns of which were "pure" sized as is usually the case with this class of goods. On examination it was found that the cloth was stained, but the stain appeared only where the coloured border had been folded in contact with the grey cloth.

One expert on behalf of the manufacturer said that the stains were due to the dye having run when the goods were pressed in the packing, and that the fault was due to inferior dyeing. Another, who was acting for the merchant, reported that the damage was caused through the use of bad tallow in the "mixing." The analyst for the dyers of the yarns said that the stains were due to mildew, but he was unable to say how they were caused, because he had found by an analysis of the cloth that it contained a very large proportion of chloride of zinc. In fact, so far as the body of the cloth was concerned, the conditions were altogether unfavourable to the development of mildew.

A careful examination of the border showed that it was mildewed. This mildew was caused by the coloured yarns having been "taped" too damp. It had developed whilst the yarn and cloth were in the weaving shed, but the dark colours of the dye had hidden it. After the cloth was packed and pressed

the mildew had "marked off" on the grey cloth, thus making its presence apparent.

It is a well-known fact amongst all makers of coloured bordered goods containing "heavy" sized grey yarns and "pure" sized coloured yarns, that there is a great danger of mildew forming if the coloured borders are not run very dry. Attention has already been called to the importance of running the coloured yarn dryer than the grey yarn on page 385. In this particular case no precautions had been taken to dry the coloured yarn more than the grey yarns. The manufacturer had neither a special drying cylinder, nor had he arranged to run the yarn next to the face of the cylinder, as described on page 386. This is a matter which should be more seriously considered by manufacturers of coloured bordered goods. If the coloured yarns were run through a "size" containing some form of preservative a great deal of the danger would be removed. Chloride of zinc is not suitable for certain coloured yarns, as it affects the colours, but there is no such objection to the use of salicylic acid or carbolic acid, and these substances are sufficiently powerful to prevent mildew if rightly used.

Mildew is very often formed on goods which are woven with a number of thick threads or cords in the selvedge. The reason of this is that the thick threads can be dried properly only with the

greatest difficulty. It would be better to “cramp” a number of threads through the heald instead of using one thick thread where a cord is required. The same effect would be produced in the cloth, and the finer threads could be thoroughly dried when passing over the drying cylinders. As a further precaution it would be advisable to use salicylic acid in the “size” for all goods which contain selvages made from thicker yarns than those contained in the body of the cloth.

IRON STAINS:

THEIR ORIGIN, DEVELOPMENT, AND PREVENTION.

Iron-stains are a prolific source of annoyance and loss to manufacturers of “grey” cotton cloth. The origin of these stains may be traced to many sources. Very often they occur where iron does not exist as an impurity in the “size” itself. For convenience of description the authors have divided iron-stains into three classes, viz.:—

(1) Stains which occur in the form of a broad band across the piece of cloth. These stains generally occur in the spring and summer, and disappear after a time without any apparent cause.

(2) Stains which occur in the form of spots, and patches, and which develop after the cloth has been woven.

(3) Stains which are due to apparent causes, such as water dropping on the cloth in the loom, "black oil," etc., etc.

CLOTH STAINED WITH A BROAD BAND ACROSS THE PIECE.—This class of stains is caused by the yarn and cloth coming in contact with iron portions of the loom which have rusted, such as the reeds, the temple roller, and the front rest. Under ordinary circumstances the size should not exert any corrosive action on the loom, but if the conditions are suitable rusting will take place, and the stains will form on the cloth by rubbing against these rusty places. This, in very bad cases, will occur in a single night, but generally it takes place during the week-end, when the looms are stopped for a longer period. The stain first shows on the front rest and temple roller, and afterwards on the warp which has passed through the reeds after the loom has been running a minute or two. This stain continues to form until the rust is removed by the friction of the yarn.

The rusting of the loom may be due to several causes:—

(1) To the presence of acids in the sizing ingredients.

(2) To the presence of acids in the water used.

(3) To the presence of too small a proportion of tallow, and too large a proportion of deliquescent

substances, such as the chlorides of magnesium and calcium, in the size.

(1) The presence of acid in the size may be detected by means of blue litmus paper, as previously directed. If acid be present, it is necessary to find which ingredient contains it. The various ingredients should be carefully tested for acid as directed. The water used for the "mixing" should be most carefully tested, as it is very often the source of the trouble, especially where the proportion of tallow in the size is rather small.

Sometimes this rusting of the loom occurs intermittently. There does not seem to be any apparent cause why it develops or why it disappears, as no change has been made in the size "mixing." Where this condition exists it will generally be found that the manufacturer ferments his flour. As the products of fermentation will vary according to the class of flour being treated, it is possible at one time to get a very acid product, whilst at another time there may be very little acid produced. Fermented flour should always be neutralised with alkali. This would prevent iron-stains arising from this source.

Tallow, which contains acid, may be the cause of the trouble, especially if it contains mineral acid. One consignment may contain acid, whilst the next may be quite free from it. This would cause the loom to rust at one time, and not at another.

The water used for the size "mixings" may give rise to two forms of iron-stains. One form may be produced by the acids contained in it acting on the loom, and the other by their acting on the pipes through which the water passes.

Many cases have occurred where iron-stains have formed through the "taper" using water which has stood over-night in the pipes for diluting his size. The pipes have become corroded and the rust has been carried down when the first water has been run out. The effect of this would be to form iron-stains which would probably develop during the time the yarn is being woven into cloth.

Corrosion of the pipes is not always due to acids in the water. Chloride of magnesium will also cause iron pipes to rust. It would be better and safer if all pipes, from which water is drawn by the "taper" for diluting his size, were made of copper.

The most general cause of iron-stains, produced by the rusting of the looms, is the use of too small a proportion of tallow and too large a proportion of chloride of magnesium in the size. Where this condition exists there is not sufficient greasy matter present to protect the looms from rusting when the moisture from the atmosphere settles upon the yarn at night as the weaving shed cools. This moisture will be more readily absorbed in the presence of a large proportion of chloride of magnesium.

In a paper recently given in Manchester it was stated that the foregoing explanation was not the true cause of the looms rusting. The theory was put forward that the rusting was due to minute traces of chlorate of potash, or chlorate of soda, in the chloride of zinc. These salts are used for oxidizing ferrous iron to the ferric state previous to its precipitation as ferric carbonate in the manufacture of the chloride of zinc. This theory of chlorate of potash being the cause of looms rusting is rather a "far-fetched" one. Iron-stains of this character occur almost invariably in "heavy" sized goods, and generally in those sized over 100 per cent. The proportion of chlorate of potash in the chloride of zinc, is, in the first place, infinitesimal, therefore the proportion in the total "mixing" must be exceedingly minute. The analysis of chloride of zinc, as given by the author of the paper, is as follows:—

	No. 1.	No. 2.
Chloride of Zinc	44·63	44·94
Oxide of Zinc	0·38	1·49
Chloride of Ammonium...	2·05	absent
Sulphate of Sodium.....	1·27	trace
Chlorate of Sodium.....	0·28	0·31
Water	51·39	53·26
	<hr/> 100·00 <hr/>	<hr/> 100·00 <hr/>

From this we may gather that the average amount of chlorate of soda or chlorate of potash is 0·3 per cent. As "mixings" increase in

weight the proportion of chloride of zinc decreases, because the proportion of flour or starch decreases. The following "mixing" gives the proportions of the various ingredients required for 140 per cent. of size :—

Chloride of Magnesium at 60° T.,			
	35 gallons =	140	pounds (solid)
China Clay.....	1792	„	
Tallow	230	„	
Flour and Starch	460	„	
Chloride of Zinc at 102° T.,			
	6½ gallons =	45	„ (solid)
		<hr/> 2667	

N.B.—45 pounds of solid chloride of zinc is equal to about 100 pounds of the ordinary solution at 102° T., and will therefore represent 0·3 pounds of chlorate of potash or soda.

The total weight of solids in the above "mixing" amounts to nearly 2700 pounds, and in this, according to the average analysis, will be found 0·3 pounds (= about five ounces) of chlorate of soda. Therefore about five ounces of chlorate of soda will be mixed with *forty-two thousand seven hundred ounces* of size. To assert that this small quantity of chlorate of potash or soda is the true cause of looms rusting is absurd, and it is simply an attempt to make a theory fit in with established facts. So small a proportion of chlorate of potash or soda would be simply "smothered," and could not possibly exert any rusting action on the looms.

The curious part about this form of iron-staining is that it occurs usually in the spring and summer. This is actually the case where zinc, containing chlorates, is in use all the year. There is a very simple explanation for this. It is entirely a question of inside and outside temperatures affecting the amount of condensation of moisture in the weaving shed. In the winter the outside walls and the glass are very cold, and consequently the moisture in the atmosphere of the weaving shed condenses on the walls and glass very quickly. On the other hand, in the summer, instead of the condensation taking place rapidly, and being localised to the walls and glass, it takes place gradually during the night. The effect of this is that the moisture is attracted by the chloride of magnesium, and settles on the looms to a greater extent than it does in the colder months of the year. If there be not a sufficient quantity of tallow present in the size the moisture will cause the *iron to rust*.

The reader must remember that a manufacturer never uses excessive proportions of both chloride of magnesium and tallow, for if he did the yarns would be too "soft." Therefore, if an excessive quantity of chloride of magnesium be used, there is almost certain to be an insufficient quantity of tallow.

Frequently a "mixing" which would cause the loom to rust in one shed would not do so in another, and for this reason the authors do not think it

desirable to publish details of many "mixings" which have been known to cause iron-stains.

There is one remedy for these iron-stains. Whenever they occur the quantity of tallow used in the "mixing" should be increased and the proportion of chloride of magnesium should be reduced. The extra tallow will form a greasy surface on the warp and on the cloth, and this will keep the reeds and other portions of the looms from rusting. The tallow must of course be free from acid.

CLOTH SPOTTED OVER WITH IRON-STAINS.—This class of stains may occur through many causes. They are generally due to the presence of iron in some form in the sizing ingredients. The most likely ingredients are the chlorides of zinc, magnesium, and calcium, or the water used for making the "mixing," or diluting the size in the "sow" box.

It has already been mentioned on pages 535 and 536 that certain waters cause iron pipes to rust, and if this rust is carried into the size iron-stains are certain to form. It has also been mentioned on page 228 that chloride of calcium is liable to cause iron-stains if it be impure. The two impurities likely to cause these stains are hypochlorite of calcium, which acts upon iron and causes it to rust, and chloride of iron, which will produce iron-stains of itself. Many cases arising from these sources have come under the writer's notice of recent years, and one is mentioned on page 229.

Iron-stains which are due to the causes mentioned above, generally develop during the weaving or after the cloth has been stored for some time.

Iron-stains are sometimes formed in the weaving shed by water dropping upon the cloth from a rusty iron beam. The water carries the iron rust down with it, and, if it be not noticed by the weaver, it will pass through several folds of the cloth, as it winds on the roller. Water produced by condensation will also produce iron-stains if it drops upon the cloth which is in contact with the iron of the loom. The loom quickly rusts and this is transferred to the cloth.

Iron-stains are very often caused by the cloth coming in contact with oil which has been used for lubricating the bearings of the loom. This kind of stain is known as "black oil stain," and will have the appearance of ordinary iron-stain when the oil is removed, unless the oil be taken out immediately.

TESTS FOR IRON-STAINS.

1st.—Burn a portion of the cloth containing the stain, and compare the ash produced with that obtained by burning an unstained portion of the same size, as described on page 516. Dissolve each ash in dilute hydrochloric acid in separate test tubes, and dilute each with distilled water so as to make 50 c.c.

of solution. To each of the solutions add two drops of ferrocyanide of potassium solution. The ash containing iron will give a deep blue colour, whilst the other should have a faint blue colour only.

2nd.—Immerse a portion of the stained cloth and a portion of the unstained cloth in a mixture of dilute hydrochloric acid and dilute solution of ferrocyanide of potassium. The portion showing the stain will develop an intense blue colour if it be due to iron.

3rd.—Immerse a portion of the stained cloth and a portion of the unstained cloth in a dilute solution of nitric acid and sulphocyanide of potassium. The stained portion will develop a blood-red colouration if iron be present.

REMOVAL OF IRON-STAINS.—If iron-stains are caused through coming in contact with “black oil” they should be immediately treated with benzene to remove the oil and afterwards treated with a solution of binoxalate of potash, commonly known as “salts of lemon.” Oxalic acid is frequently used for this purpose, but it is much more injurious to the cloth than salts of lemon.

If the iron-stain be a very fast one it may be removed by first treating it with dilute hydrochloric acid, and afterwards rubbing it with a crystal of sulphate of copper. These chemicals must be entirely removed by washing the cloth in clean water afterwards.

“Where “black oil” has come in contact with cloth great care should be taken in removing it, especially if the cloth has to be bleached, dyed, and “finished.” If the mineral oil be not entirely removed the bleached cloth will contain yellow stains, and if it be intended for dyeing the stained portion will not take the dye properly. See chapter on bleaching. It is also very essential that every trace of oxalic acid, or of the “salts of lemon,” should be washed out of the cloth, especially if the goods are intended for bleaching. Wherever the bleaching liquor comes in contact with a portion of the cloth which has been treated with the above chemicals, and where it has not been thoroughly washed, the cloth will be more or less tendered through the formation of oxycellulose.

All forms of iron-stains which have been discussed are due to manufacturers’ faults, or at any rate, to the faults of those for whom the manufacturer is responsible. Sometimes cloth becomes iron-stained through careless or inferior packing. In order to determine the responsibility in such a case a bale of the cloth, together with the packing, should be examined very carefully. The writer knows many instances where the manufacturer has been held to blame, and has had to submit to deductions, where the stain has been due to the paper used in packing.

Brown paper always contains oxide of iron, and if this paper be placed in direct contact with

“heavily” sized shirtings, a portion of the oxide of iron is sure to be absorbed. This stain may be carried through many folds of the cloth. Brown paper should never be placed in direct contact with the cloth, but should always have a layer or layers of white paper between it and the goods.

CHAPTER XV.

Bleaching.

Faults in Sized Cloth which cause Damage when Bleached and Finished.

THIS chapter has been written with the object of giving cotton manufacturers a clear insight into the treatment cloth receives at the hands of the bleacher, and to show how damage may occur through faults in sizing. It is not intended to be a full and detailed description of bleaching.

The object of bleaching cotton cloth is to remove or destroy the natural colouring matter of the fibre and render the fabric white or colourless.

Chemical bleaching has long superseded the old-fashioned methods of subjecting the cotton cloth to the action of light, air, and moisture, known as "crofting."

The principal agents used for the chemical bleaching of cotton goods are chlorinated lime, chlorinated soda, slacked lime, soda ash, washing soda or soda crystals, caustic soda, soap, and acids, such as sulphuric, hydrochloric, and acetic acid.

The following is a summary of the usual processes employed in bleaching cotton goods:—

1. STAMPING AND SEWING.
2. SINGEING.
3. WASHING AND STEEPING.
4. WASHING AND LIMEING.
5. "BOWKING" OR BOILING WITH MILK OF LIME.
6. WASHING.
7. SOURING IN ACID.
8. WASHING.
9. SCOURING WITH CAUSTIC ALKALIES.
10. WASHING.
11. IMMERSING IN BLEACHING LIQUOR.
12. WASHING.
13. SOURING IN ACID.
14. WASHING.

The actual method of carrying out these various operations in a practical manner will now be dealt with in detail.

THE PRACTICAL BLEACHING OF COTTON PIECE GOODS.

After leaving the manufacturer the cloth is sent to the bleach works. Here it may have to be stored for several months waiting instructions from the merchant. When this is the case the number of pieces must be checked on arrival, and a few from

each lot examined for faults. It is not always possible to examine each piece separately at this stage on account of the time required.

The cloth should be stored on stillages in the grey room. These stillages are raised about six inches from the floor so as to allow a free circulation of air under and around the bundles. Great care must be exercised in the storage of cotton cloth, as it has frequently to remain in this position for a considerable period. Should it be imperfectly stored it is highly probable that a development of mildew will take place. This may mean considerable loss to the bleacher who is responsible for the cloth whilst in his charge.

Cloth frequently arrives at the bleach works already mildewed. When this is the case its condition should be noted, and a request for instructions sent immediately to the merchant or manufacturer. If such a cloth be bleached within a week or two of its arrival there need be no fear of further damage, as the mildew growths attack the starchy matters of the size first, and it is only after prolonged contact that the cotton fibre is deteriorated. As a matter of fact, if such mildewed cloth be well stored, with free access of air, it is probable that the mildew will remain dormant, if it be not actually destroyed.

When orders are received the cloth is taken from stock and carefully examined. The quality, length, width, and weight, should be noted, and

the number of threads in the weft and warp per square quarter inch counted. It is advisable to cut off samples for reference in case any dispute may arise. The presence of mineral oil stains and other forms of damage, etc., should be carefully looked for, and all particulars noted and entered in the "grey book." These particulars will be required in all the processes which follow the bleaching, and will, if systematically and correctly entered, save much time and annoyance at a later stage.

In order to carry out the bleaching operations successfully it is essential that different classes and qualities of cloth should receive treatment according to the nature of the goods, for instance:—

Light goods require to be subjected to less treatment than heavy goods, therefore the two classes of cloth must be kept separate.

If heavy goods and light goods were put through the same treatment, with the same strength of liquors, the latter might be tendered through excessive bleaching, or the former might be half bleached only.

In determining the treatment in order to obtain a good and even bleach the quality of the cloth must always be taken into consideration also.

STAMPING AND STITCHING.—The pieces are stamped with the number assigned to them. They are then conveyed to the stitching machine, where

they are sewn end to end and made up into batches of two or three tons.

SINGEING.—The operation of singeing is carried out for the purpose of removing the short fibres or fluff always present in grey cloth. Should this fluff not be removed the face of the cloth will have a matted and raw appearance when “finished,” instead of having the gloss which a perfectly singed cloth should have.

There are two methods of singeing in use at the present time. One is known as “the hot plate” process, the other as the “gas” singeing process. In the former the machine employed consists essentially of two copper plates, semi-circular in shape, which are heated underneath by means of a furnace. The chief objection to this method is that very often the plates are not kept at a uniform temperature. If this occurs the cloth is unevenly singed and it gives a bad effect when “finished.”

The gas singeing machine is superior to the plate machine, and it is more readily prepared for the operation. It gives a more even singe and it is better adapted for all classes of work. This is especially the case where corded and ribbed cloths have to be singed. The flame is able to get between the ribs, whereas only the fibre from the upper surface of the cord would be removed by the plate machine. The authors would here point out the absolute necessity of keeping an even flame on gas

singeing machines. Many cases of damaged and tendered cloth have been caused by the flame being higher at one portion of the burner than at another, thus causing the gas jet to impinge more on one portion of the cloth than on the other. This would scorch and tender the cloth, more especially if chloride of magnesium be present. The tendering would be most in evidence along that portion of the cloth which was over-singed.

After the cloth has been prepared in the way described it is ready for bleaching.

STEEPING.—The cloth is first wet out with hot water by passing it through a washing machine. It is then plaited and laid out in a pile and allowed to stand for 12 or 14 hours. This is termed the “rotten steep,” the object of which is to produce a decomposition in the starchy matter of the size, and so render it more easily removed in the washing process which follows. It also allows the chemicals to act more readily on the fibres at a later stage, and prevents the lime liquor from becoming contaminated with size to the same extent as it would otherwise be.

WASHING.—At least two washing machines should be used in a bleach croft. It is important that each should have an abundant supply of water. These machines should be in a line between the “sour” and “chemic” cisterns, and should be arranged and geared so as to work conjointly.

With this arrangement the cloth can be washed twice in one run. It will be necessary to fix a winch between the two machines so that machine No. 1 can be threaded up, thus allowing a certain amount of slack cloth to run into a receptacle, and enabling it to be threaded through machine No. 2. All draw winches in a bleach croft should be arranged so that they are thrown in or out of gear on starting or stopping the washing and liming machines. If the winches are not arranged in this way they will continue revolving, and this has a tendency to damage the cloth, which rests upon them, by displacing the threads. This is especially so in satin cloths.

It may be mentioned here that it is absolutely necessary to have an ample supply of good water, and that the cloth should be thoroughly washed after every process. This is specially important when the cloth has reached the condition of being nearly white. It will be of advantage to the bleacher if he keeps a memorandum of how he treats each "batch" of cloth, so that he will have a practical guide in future operations.

LIMEING.—The process of limeing consists of running the cloth through milk of lime (calcium hydrate), in the limeing machine, and then into the kiers. A sufficient volume of lime liquor must be present in the machine box to ensure a thorough saturation of the cloth during its passage to the kier.

“BOWKING” OR BOILING WITH LIME.—After passing through the limeing machine the cloth is ready for treatment with lime in the kiers.

In many bleachworks the kiers are arranged only for low pressure boiling, but high pressure kiers are preferable in many cases. This is especially so where “heavy” goods have to be treated. The increase of temperature of high pressure steam greatly facilitates the cleansing operation. Low pressure kiers are the best for low qualities of cloth, as high pressure steam is more liable to damage a thin fabric. This also applies to goods with coloured borders and “headings.”

All kiers must be thoroughly lime-washed every few weeks, first cleaning the interior of all the rust and dirty matter which may have accumulated. The lime-wash may be more readily applied if it be done soon after the kier has been emptied, and whilst the iron is still hot, as it dries and hardens more quickly under these conditions. Particular care should be taken that every portion of the kier is covered with lime. If any portion be left unprotected the cloth will become iron-stained.

It is a decided advantage, where it can be arranged, to use the kiers alternately, first for lime boiling and then for ash boiling.

The greatest care must be exercised to have sufficient lime liquor in the kiers to thoroughly

immerse the cloth during the process of boiling, and the boiling must be conducted evenly and regularly. Boiling milk of lime, even under pressure, has no detrimental action upon cotton so long as the cloth is entirely immersed, but if any portion be exposed tendering takes place.

In the case of strong cloth the boiling with lime liquor should be continued for at least six hours under a pressure of 30 pounds, but if the cloth be of low quality the boiling must be conducted at the ordinary pressure. After boiling it should stand for a few hours, care being taken that the kier is filled with water so as to entirely cover the cloth. Should this be neglected and any portion become dry, stains would probably be developed and more or less tendering take place.

Particular attention must be paid to the manner in which the cloth is plaited down in the kiers. It should be laid in long even layers and not allowed to collect in heaps, or the result will be an uneven bleach, due to the coils preventing a free circulation of the liquor through the cloth. In high pressure kiers it may cause the cloth to be perforated or "shot." This condition is brought about by the steam trying to force its way through the lumpy places. Many bleachers consider that these "shot" holes are caused during the "souring," but they are actually formed during the lime boiling process. It is a fact that strong heavy fabrics

are more affected than light fabrics, and linen even more than cotton. If the cloth be properly arranged, and not simply dumped into the kiers, the steam and liquid penetrates easily and thoroughly and "shot" holes are rarely formed.

It is important to remember that the success of bleaching, dyeing, printing, and finishing, depends upon the cloth being well "bottomed." Unless this condition be attained the cloth will not absorb the colours properly in dyeing and printing, and will resist the starch and moisture ("conditioning") in "finishing." The cloth will also have a soft and greasy feel, with a creamy tint, instead of being white. It will be seen therefore, how much the success of the after processes depends upon the thoroughness of the boiling.

After being boiled in the kier the cloth must be thoroughly washed again, and afterwards conducted to the cisterns to be treated with acid, *i.e.*, the "souring" process.

"SOURING."—In this operation the cloth is treated with dilute hydrochloric acid (spirits of salts) or sulphuric acid (vitriol). The "souring" at this stage being known as the "grey sour." The operation should be conducted in stone cisterns.

The acid solution, known as "sour," is made to Twaddell at about one to three degrees, according to the quality of the cloth. A strong cloth

resists the acid more than one of a low grade. The acid solution is prepared beforehand in a cistern underneath that containing the cloth and it is sprinkled over the cloth by means of a centrifugal pump and a rose sprinkler. The pipe leading from the pump must be made of lead, as this metal is not acted upon by weak acids. The same metal is also used for the solution of "chemic." It is necessary, of course, to have separate pumps for the acid and "chemic" solutions.

In mixing the "sours" it is advisable to dilute the strong acid with about twice its volume of water. It will then be found to mix in the "sour" much better.

Whenever it is required to dilute sulphuric acid the acid should be poured slowly into the water and agitated. Water should never be poured into strong sulphuric acid.

Some bleachers prefer sulphuric acid (vitriol) solution as a "sour," but it has certain objectionable features which hydrochloric acid has not. It is hardly possible to remove the whole of the lime introduced into the cloth in the previous operation by washing, and should any be left in the fabric, the sulphuric acid will convert it into sulphate of lime. This substance is developed within the fibre itself, and being almost insoluble, it is nearly impossible to remove it afterwards.

Sulphate of lime will cause stains, known as lime-stains, to be formed. These patches of sulphate of

lime, besides causing the cloth to have a harsh feel, will be detrimental in the later processes of dyeing and printing. Hydrochloric acid "sour" has no such objectionable property. This acid forms a soluble salt of lime which is very easily removed by washing.

Another method of "souring," sometimes employed, is to pass the cloth through one of the washing machines containing acid liquor. A pipe is fixed to the machine and this is connected with a cistern containing the "sour." The box of the machine should be kept well filled with the "sour" until the process is completed. The cloth is plaited into a pile as it leaves the machine, or it is conducted to a stone cistern where it is allowed to stand from one to four hours. This process clears the cloth of the lime and all superfluous matter which may remain in it after limeing.

Grey limeing and "souring" must be thoroughly conducted. Careful attention to details is amply repaid at a later stage.

After "grey souring" the cloth should be thoroughly washed through the washing machines and squeezed as dry as possible. The reason for this is, that if the cloth contained a large quantity of moisture it would dilute the soda ash liquor in the next process. After washing and squeezing, the cloth is taken to the "ash kier" for treatment with soda ash.

SODA ASH BOIL.—In this operation the cloth is placed in the kier and carefully and evenly arranged. This is done, as a rule, by boys. It is necessary that the clogs worn by the boys should not have the usual irons on the soles, nor should there be any iron nails used in their construction. Brass nails are not objectionable.

For strong and "heavy" goods 3 pounds of soda ash will be required for each 112 pounds of cloth. For low qualities $1\frac{1}{2}$ pounds will be sufficient. At this stage it will be found beneficial to use resin soap in the proportion of about $\frac{1}{2}$ per cent. of the weight of cloth. This soap not only cleanses efficiently but it greatly facilitates the "finishing."

The cloth is boiled for the same length of time and under the same conditions as described under lime boiling on page 553. It is then allowed to stand in the solution for about eight hours; the same precautions being taken again to fill up the kier with boiling water. The cloth is then thoroughly washed and run into a stone cistern, where it is impregnated with a solution of bleaching powder ("chemic").

"CHEMICKING."—In this operation, the cloth is treated with a solution of bleaching powder. The cloth must be thoroughly immersed in the solution, and the sprinklers kept constantly working. Should any portion of the cloth be exposed to the atmosphere during this operation it will be made whiter than

that unexposed. This is due to the quicker liberation of hypochlorous acid from the "chemic," brought about by the action of atmospheric carbon dioxide and light.

The bleaching liquor should be made of a strength Twaddelling about $1\frac{1}{2}$ to $2\frac{1}{2}$ degrees, the bleacher here using his own judgment as to the particular strength necessary for the class of cloth he may be treating. It is found that cloth made from Egyptian cotton requires a stronger liquor than that made from American cotton.

The cloth should remain in the "chemic" for about four hours. It is then well washed and afterwards run into the "sour" cisterns to undergo treatment with acid once again. If the cloth be intended for dyeing or printing, hydrochloric acid, Twaddelling $1\frac{1}{2}$ to 2 degrees, should be used. It should remain immersed in a liquor of this strength from three to four hours, after which it should be thoroughly washed. The cloth is then ready for the squeezing machine.

"PURE" WHITE GOODS.

If the cloth be intended for "pure" white goods it will have to undergo further treatment. It will be necessary to boil again in the "ash kiers" with a further quantity of soda ash, after which it should be washed, re-chemicked, washed again, and afterwards "white soured." In this "souring," weak

sulphuric acid is used. This should not exceed one degree in strength as shown by the Twaddell's hydrometer. The "ash" and bleaching liquors should be much weaker than those used in the first treatment, as this latter process is required only as a final clearing. It will also be found advantageous to use a small quantity of soft soap during the boiling in soda ash.

After "white souring" the cloth is ready for the final wash, and this must be thoroughly done. No possible injury can occur to the fabric by the various washings, and each one further cleanses it.

After washing out the "white sours" it is advisable to pass the cloth through a weak solution of ammonia contained in the squeezing machine. This will neutralise any remaining trace of acid, especially in "heavy" goods from which the acid is not entirely removed. Should any free acid be left the cloth will be tendered on drying.

A little ultramarine blue may be mixed with the ammonia solution, care being taken that the liquor is not "blued" too much, for if this is the case the cloth will be streaky. This effect is caused on account of the cloth being squeezed in the form of a rope. It should be left to the "finisher" to produce the right shade or tint.

After squeezing, the cloth is ready for the "white mangle," which should have a scutching machine attached to it.

Cloth which is intended for "whites" or for printing should be dried as soon as possible and stored in a cool dry place. If left wet for any length of time it will become "weather struck," and turn yellow, this being due to some parts of the cloth drying more slowly than others. If the cloth is for dyeing it can be made into suitable "batches" and left in the wet state, it being unnecessary in this case to dry after mangling.

CAUSTIC SODA PROCESS OF BLEACHING.

This process consists of boiling the cloth in a solution of caustic soda instead of in lime (milk of lime) and soda ash. The process will be found to answer very well where the cloth is for printing and dyeing. It is important that a fair amount of resin soap should be used in this process, otherwise the cloth will turn up very soft and greasy when "finished." The following is the method of procedure:—

After singeing, the cloth is allowed to steep as previously described on page 550. It is then boiled for six hours in a solution of caustic soda and resin soap. For ordinary qualities of cloth a solution of caustic soda Twaddelling 3 degrees may be used, but for low qualities of cloth a weaker solution should be used. For each 100 pounds of cloth

three-quarters of a pound of resin soap should be added.

After boiling, the cloth is allowed to steep in the liquor as described on page 353, and afterwards well washed. It is then "soured" with hydrochloric acid, washed, and again boiled for six hours in a solution of caustic soda Twaddelling about 1 to 2 degrees. After boiling, the cloth is again allowed to steep as before, then well washed, and finally treated with bleaching liquor Twaddelling $1\frac{1}{2}$ to $2\frac{1}{2}$ degrees. The cloth should lie in this liquor from two to four hours, the sprinklers being kept working during this time.

After "chemicking," the cloth is again well washed, then "soured" with the "white sour" (sulphuric acid) Twaddelling about 1 to 2 degrees, and allowed to lie as previously described. It is then well washed, after which it is ready for squeezing, scutching, and mangling.

THE "SCOURING" OF COTTON GOODS.

This process is carried out where cloth has afterwards to be dyed some dark shade as in the case of aniline black. In preparing what are known as "scoured" or "half-bleached" goods the following procedure is adopted:—

The methods described on page 547 and the following pages, up to, and including the process of

boiling in soda ash, are carried out, using the same strength of liquors. At each of the stages of steeping and boiling the methods of procedure are the same.

After the cloth has been boiled in the soda ash kier and steeped, it should be well washed and run into the "sour" cistern, where it undergoes a "souring" with hydrochloric acid, Twaddelling 3 degrees. The cloth is then well washed to remove all traces of acid. This completes the process.

It is the custom of some bleachers not to "sour" after boiling in the soda ash. They prefer, after washing out the "ash," to take the cloth right to the squeezer. This is not a good method as it will be found that "souring" at this stage materially helps to whiten the cloth, and will be of advantage both to the bleacher and the finisher.

OPEN BLEACHING,

OR THE MANIPULATION OF THE CLOTH IN THE
OPEN WIDTH,

The process of "open bleaching," where it can be adopted, is desirable for certain classes of goods in which the face of the cloth is liable to become damaged in passing through the various machines in the rope form. This is the case with such cloths as satins, satteens, flannelettes, piqués, "bedford" cords, brocades, etc.

There are many machines on the market for this method of bleaching, but the procedure is practically the same in every case, and may be summarised as follows:—Sorting, Stamping, Sewing, Singeing, Washing in Steep, Running through Boiling Caustic Soda Liquor, Steeping, Washing, Souring, Washing, Chemicking, Washing, Souring, and the final Wash. The strength of the liquors varies according to the kiers used, and to the quality of the cloth to be treated. The experience gained by following out the instructions given in the preceding pages will be sufficient to enable the practical reader to carry out the processes.

GENERAL INSTRUCTIONS.

In carrying out the bleaching operations the following essential precautions should be observed:—

(1) Care must be taken that the cloth does not get splashed with bleaching liquor or mineral acid “sours,” especially vitriol, as these liquids have a tendency to produce white spots in the fabric, especially in “scoured” goods.

(2) Care must be taken that the cloth is not subjected to any undue strain in its various movements during the different processes, as this will cause such cloths as drills, satins, sateens, etc., to crack on the selvages. This is much more the case with these than with ordinary plain cloth. The tension

must therefore be watched and regulated so as to avoid any undue strain.

(3) In the case of lawns, handkerchiefs, and other very light goods, it is better to hand "scutch" than to employ a "scutching" machine. In the former operation the headings and borders are kept much straighter and there is not the same risk of damage as when the machine is used.

In conclusion the authors would again point out that there is only one way to ensure success in bleaching, and that is *by thoroughly "bottoming" the cloth in the boiling operations.* Any attempt to shorten the operations cannot meet with success. A good many bleachers have tried to obtain good whites by using stronger "chemic" and boiling less but with one result only, *i.e.*, bad work. The cloth may look white at first but when it is kept for some time it begins to come up brown or yellow.

THE BLEACHING OF COTTON GOODS WOVEN WITH COLOURED BORDERS AND HEADINGS.

Dhooties, towels, handkerchiefs, and other cotton goods which are woven with coloured borders and headings have frequently to be bleached. They require more careful treatment than ordinary whites and prints, and they are very often damaged in the course of bleaching.

The coloured yarns used in the manufacture of such cloth should be dyed with materials capable of withstanding the bleach, otherwise the colours will be damaged or entirely destroyed. Cases repeatedly come under the writer's notice in which coloured yarns have been used, especially for the headings, which have been utterly unfit for the purpose. In some instances this has been due to carelessness or lack of knowledge on the part of the manufacturer, whilst in other cases it has been due to being misled by the dyers of the yarn.

The chief colours which may be satisfactorily employed to stand bleaching are the following:—

1. Red—Alizarine Red
2. Pink—Alizarine Pink
3. Orange—Alizarine Orange
4. Yellow—Alizarine Yellow
5. Chocolate—Alizarine Chocolate
6. Purple—Alizarine Purple
7. Heliotrope—Alizarine Heliotrope
8. Buff—Catechu or Cutch
9. Brown— do. do.
10. Blue—Indigo
11. Black—Aniline Black

THE INDANTHRENE SERIES OF COLOURS.—The indanthrene colours are a new series of colours which have been introduced recently. Indanthrene (blue) is employed as a substitute for Indigo. Mixtures of indanthrene and flavanthrene produce various shades of green. The indanthrene colours have been much improved recently and they are

being successfully used at the present time for headings and borders. The very greatest care has to be exercised, however, in the bleaching, otherwise they bleed and "mark off," and no process can remove the stains, after they have once formed, without destroying the fabric. It is in the kier where the damage is done. Indanthrene colours should not be boiled, the temperature of the alkaline liquor being kept below 200° Fah. Some of the colours will not stand even this temperature. Soda crystals should be employed in place of soda ash, as even a trace of free caustic alkali will cause "bleeding." All the bleaching operations should be carried out with weaker solutions than those used for the alizarines, indigo, etc., as given on pages 573 and 574.

If indanthrene colours "pale" as the result of "chemicking," they may be restored by treatment with a reducing agent such as a solution of tin crystals or titanous chloride in acid solution.

Direct and basic dyes should on no account be used for yarns which have to be subjected to bleaching, nor should mineral dyes such as chrome yellow or chrome orange be employed unless the cloth be subjected to special treatment.

Unfortunately, it is the practice of many dyers to obtain the desired shade by "topping" (*i.e.*, by applying a basic dye to the original colour after the first bath). By this means they obtain brightness and intensity of shade at a less cost and with a smaller

amount of the proper colour. Thus, alizarine red is frequently "topped" with *magenta*, alizarine purple with *violet*, alizarine yellow and orange with *auramine*, buff and brown with *Bismarck*, indigo blue with a *direct blue*, and aniline black with *logwood* and *direct black*. In fact, the authors know of cases where *logwood* and *direct black* have been substituted entirely for aniline black.

Where such "topping," or entire substitution takes place, the colours are sure to suffer in the bleaching processes. It is therefore to the interest of both manufacturer and bleacher that the colours should be carefully tested before proceeding with the manufacture or bleaching of the cloth. By taking this precaution damage and subsequent disputes would be avoided and the bleacher particularly would be safeguarded against responsibility for spoiled cloth. It would be very difficult to place the responsibility after the goods have been bleached, especially where the dyes have been "topped" and not altogether substituted. In such a case an analysis would show that the correct colour had been used (the colour used for "topping" having been destroyed in the bleach), and the probability would be, in case of dispute, that the dyer would assert that the goods had been improperly treated. It will be readily seen therefore, that unless the bleacher takes the precaution to keep a sample of the unbleached cloth, as directed on page 548, he

would probably be held liable for damage caused through no fault of his own.

Should the tests for the colours be applied as here directed, and basic, or direct, or other objectionable colours be found, the bleacher should at once give notice to the manufacturer or merchant before proceeding further, thus clearing himself of all responsibility for the results.

Damaged headings are also frequently caused by manufacturers using cops of weft of the right shade, but dyed with unsuitable dyes for bleaching, along with coloured weft which will stand the bleaching. The result is that one portion of the coloured heading is destroyed whilst the other remains alright.

TESTS TO BE APPLIED TO DETERMINE THE DYES ON COLOURED BORDERS AND HEADINGS.

(1) TEST FOR PRESENCE OF BASIC DYES ON ALIZARINE.—Treat a small portion of the coloured border with acetic acid, and press between white blotting paper. If any basic colour has been used a distinct colouration will be apparent on the blotting paper.

(2) TEST FOR PRIMULINE RED.—Treat a portion of the coloured border with solution of titanous chloride in hydrochloric acid. This will discharge the colour. Diazotise and re-develop with beta-naphtholate of soda.

(3) TEST FOR PRESENCE OF DIRECT BLUE ON INDIGO.—Treat a portion of the coloured border with nitric acid. This will discharge the indigo, leaving a buff stain surrounded by a green colouration. If this test be carefully watched any direct blue which may be present is detected by the production of a reddish stain. This stain takes longer to discharge than pure indigo. Should the red stain appear, treat another portion of the dyed border with a weak solution of bleaching powder. This will discharge the direct colour, leaving the indigo. If this portion be then well washed and treated with nitric acid, the indigo will be discharged without the production of the reddish stain.

The nitric acid should be made by mixing three parts of water with seven parts of strong nitric acid.

(4) TEST FOR INDANTHRENE BLUE.—Treat a portion of the coloured border with strong nitric acid. The colour is discharged as in the case of indigo, but may be restored by means of a solution of titanous chloride. Indigo is not restored by this treatment.

(5) TEST FOR PRESENCE OF LOGWOOD DYE.—Treat a portion of the coloured border with hydrochloric acid, a bright red stain indicates logwood.

(6) TEST FOR DIRECT BLACK ON ANILINE BLACK.—Treat the coloured border with a strong cold solution of bleaching liquor. If direct black has been used it is identified by the formation of a heavy buff

stain. If the colour be a pure aniline black the strong bleaching liquor changes it but slightly, forming a greenish black.

Sometimes yarns which are sold as "aniline black" are "topped" with a *basic* colour. This leads to damage when the goods are bleached. Very often the basic colour will mark off, especially if the fabric be subjected to pressure.

The presence of a basic dye on aniline black may be detected by means of acetic acid, as described on page 568.

A yarn may be dyed with aniline black and yet unsuitable for bleaching purposes. There are two processes of aniline black dying recognised in commerce. One is known as the "aged aniline black process," and the other as the "one bath process." In the former process the dye is faster because it has impregnated the fibre itself, whereas in the latter process the dye is more or less on the outside of the fibre. In the first case, the yarn is suitable for bleaching, but in the second case it will not stand the process. It is important therefore that the manufacturer should state definitely, when ordering black yarn, that it is intended to be woven into cloth which has to be bleached, otherwise damage is certain to occur. This damage may take the form of mauve or buff stains on the white cloth, due to the oxidation of the loose dye which has marked off and become oxidised by the chemic liquor.

The oxidised aniline black stain can be extracted from the cloth by means of alcohol, and this may be turned to account as a test for aniline black which has been dyed by the "one bath" process. The solution of dye should be diluted with water and the alcohol boiled off. Two pieces of cotton cloth, one mordanted with tannin, and the other unmordanted should be dipped into the solution. Both pieces will take the dye, but the one not mordanted can be "cleared" by washing in cold water, whereas the other is fast to this treatment.

In cases where a stain is black and it is suspected to be aniline black it should be tested by treating the cloth to a hot solution of chemic. This treatment converts the black into a buff or mauve stain which can be tested as previously described.

A case of marking-off came under the writer's notice a short time ago. The cloth which had been damaged contained a heavy Turkey-red heading. A number of black threads formed a border to this heading, and these threads had marked off when the cloth was "beetled." That the damage was not due to over-bleaching was apparent, as the cloth had a pink shade instead of being white. The pink shade was due to the bleeding of the Turkey red. An analysis of the stain showed that the aniline black had been produced in the "one-bath process," and the manufacturer was to blame for using an inferior and unsuitable yarn.

(7) TEST FOR SULPHUR COLOURS.—Boil a portion of the coloured border with water and hydrochloric acid in a suitable beaker, and test the escaping steam by means of lead acetate paper. In the presence of sulphur colours this will blacken, due to the formation of sulphide of lead by the sulphuretted hydrogen which is liberated.

Sulphur colours are very fast to light and to washing, but they are not suitable for goods which have to be bleached.

(8) TESTS FOR ORANGE CHROME (OXYCHROMATE OF LEAD) AND YELLOW CHROME (CHROMATE OF LEAD) DYES.—Treat the orange or yellow border with dilute hydrochloric acid. The colours rapidly disappear, the orange passing through various shades of yellow, until it is entirely discharged, whilst the yellow is rapidly destroyed. In each case a colourless substance, chloride of lead, is formed. The presence of the lead salt may be determined by adding to the discharged portion of the border a few drops of a solution of sulphuretted hydrogen, or sulphide of ammonium. A black stain is produced if lead be present.

A peculiar and most interesting case of damage, due to the use of orange chrome dyed yarns in conjunction with yarns dyed with Turkey orange, came under the writer's notice a few years ago. Details of this are given on page 575.

THE PRACTICAL BLEACHING OF COTTON GOODS WITH COLOURED BORDERS AND HEADINGS.

The goods are first examined and sorted, as described on page 546. They are then stamped with the respective numbers and those which require "singeing" are put through that process. The cloth is then "wet out" with hot water, and allowed to stand for about ten hours, after which it is washed. It is then run into the kier, which should be worked under ordinary pressure, and boiled for about eight hours with a liquor containing the following ingredients to each 112 lbs. of cloth:—

Soda Ash	...	...	...	1 pound.
Soft Soap	...	...	...	$\frac{1}{2}$..

The soda ash must be free from caustic soda or lime as these substances will more or less alter or destroy the colours, especially in the case of the alizarines, and the indanthrene series. After boiling, the cloth is well washed through the washing machine. It is then run into the "souring" cistern, where it is immersed in a "sour" of weak vitriol (sulphuric acid), for about two hours. The "sour" should not be stronger than $\frac{3}{4}^{\circ}$ T. From this "sour" it is well washed, and again boiled for about eight hours in soda ash and soap as before, using three-quarters-of-a-pound of soda, and half-a-pound of soap, to each 112 pounds of cloth. The cloth is again well

washed, after which it is run into the "chemic" cisterns, where it is immersed in a weak solution of bleaching liquor for about four hours. The bleaching liquor should not be stronger than $\frac{3}{4}^{\circ}$ T. It is most essential that the cloth should be entirely covered with the bleaching liquor, for if any part be exposed to the atmosphere the "chemic" will be more active in its bleaching powers, and the coloured borders will be paler in that portion exposed than in that which has been covered.

At this stage the bleacher must give the cloth the greatest attention. It is necessary to constantly examine the colours to see that the process of "whitening" is not carried too far, otherwise he will have "pale colours."

After "chemicking," the cloth is again well washed, and instead of "souring" in acid it should be run into a solution of thiosulphate of soda (hyposulphite-antichlor), containing two ounces to each gallon of water. The cloth is allowed to stand for two hours in this solution. It is then finally washed and sent to the squeezing machine.

The reason the authors advocate the use of thio-sulphate of soda, instead of an acid "sour," is that acid frequently causes the colours of the borders and headings to "mark off" and produces stains on the white portion of the cloth. One case of this kind is described on page 575, whilst another is described on pages 578 and 579.

About a yard-and-a-half of a Turkey orange bordered dhootie was submitted for analysis. On examination the cloth was found to be tinted throughout with a pink shade instead of being pure white. The experiment was tried of "souring" it with dilute hydrochloric acid, and the colour was immediately discharged, leaving the fabric white. In this case it was evident that the bleacher had omitted to clear the fabric from the chemic, either by "souring," or by use of "antichlor," but had simply washed after chemicking. It was also evident that the washing had been superficial, otherwise the chemic would not have been present in sufficient quantity to discharge the colour on treatment with dilute acid.

With the evidence obtained the writer reported that the responsibility for the damage rested with the bleacher. This was disputed, and a visit was paid to the bleach works to see the cloth in bulk. The manager at the works denied responsibility. He stated that the pink colour could not be discharged without destroying the colour of the headings. He had tried "souring," and found that he could discharge the stain, but only at the expense of the headings. Although "souring" in acid is not the proper method to adopt for coloured borders, still it should not have affected Turkey Orange to this extent and this was pointed out by the writer. He was then taken to see the cloth, some of which

had been "soured." Here it was found that the borders had stood the process, but the "headings" had not. The latter had been reduced to various shades of yellow and, in some cases, the colour had been discharged altogether. The cause of the damage was at once apparent. The manufacturer had used yarns of exactly the same shade for both the headings and the borders but in the former case the weft was dyed with orange chrome, whilst in the latter, the warp was dyed with Turkey orange. In the sample of cloth submitted to the writer for examination the "heading" was not present. Consequently, until the visit to the bleach works, he was ignorant of the fact that two distinct colours had been used. As a matter of fact it had never entered the manufacturer's mind that this could affect the results obtained after bleaching, and so long as he had used yarns identical in shade of colour, he thought he was perfectly safe. Chrome orange is not a suitable colour for borders for goods which have to be bleached, especially if a good white be required. At the same time, if this colour had been present in the cloth only, a careful bleacher would have preserved it. Even when it was used in conjunction with Turkey orange, a colour which always "runs" more or less during bleaching, it might have been kept right if the bleacher had used hyposulphite of soda for "clearing" the "chemic" instead of giving it the final "souring" in acid,

At the same time such a mixture of colours causes complications, and the bleacher can hardly be held responsible for damage caused under such circumstances.

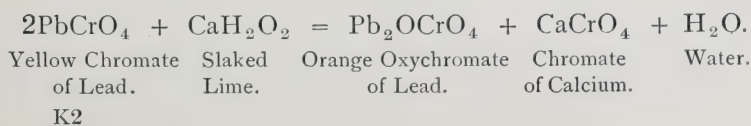
It is not generally known among bleachers that the discharged colours of orange chrome can be restored if treated quickly. If the damaged cloth had been run through boiling milk of lime in the limeing machine, after being "soured" with the acid, the colours of the headings would have been *restored*, whilst the stain on the body of the cloth from the Turkey orange would have been removed by the "souring" process.

A knowledge of the chemistry of the chrome dyes will explain this.

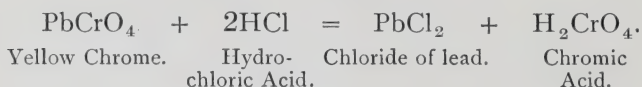
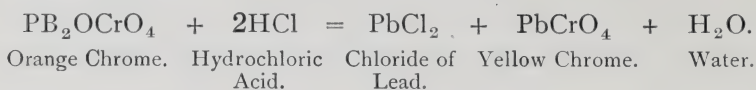
(1) Yellow chrome is a chromate of lead (PbCrO_4).

(2) Orange chrome is an oxychromate of lead (Pb_2OCrO_4), and is produced by boiling chromate of lead with milk of lime.

Both these colours are destroyed by acids; even the weakest organic acids having this effect on the orange chrome. The changes which take place in converting the yellow chromate into orange oxychromate are shown by the following equations:—



The action of dilute hydrochloric and other acids on these chromes is shown by the two following equations:—



First the orange chrome is reduced to the yellow chrome, and then, by further action of the acid, it is converted into the colourless chloride of lead.

It is doubtful however, whether this method of restoring damaged colours is of any practical value. It is interesting from a chemical point of view only. The difficulty lies in the removal of the lime left in the cloth after washing. This could only be done by “souring,” and would, of course, be as fatal as it was in the first instance.

It has already been mentioned that some bleachers only wash the cloth after “chemicking,” instead of using an “antichlor” as well. This is not a good method, as there is always a danger of leaving “chemic” in the fabric. This would injure the colours of the borders and headings, and by causing them to “run,” produce stains on the cloth, especially on that portion which has been at the bottom of the pile. Such a case is here described. The cloth was a dhootie, woven with a Turkey orange border. On examination it was found to

have a pink stain in different parts of the fabric. A more careful examination disclosed the fact that wherever the stain occurred the cloth had a harsh feel, as though some mineral substance had dried on it, and when these places were treated with dilute hydrochloric acid the colour was immediately discharged, and, at the same time the smell of "chemic" (hypochlorous acid) was given off. It was at once apparent that the cloth had not only not been treated with an "antichlor," but it was also evident that the washing was superficial as there was enough carbonate of lime present to cause an effervescence when the acid was added. The result was that the colour which had bled remained on the fabric. The bleacher was undoubtedly responsible for this fault.

Cotton cloth is frequently damaged during the processes of bleaching and the bleacher is not always to blame. Very often the trouble is due to carelessness on the part of the spinner or the manufacturer, or to the use of certain ingredients by the manufacturer in the size. The chief sources of damage which occur through faults in manufacture are generally due to the presence of :—

- (1) Mineral oil stains.
- (2) Paraffin wax stains.
- (3) The chlorides of magnesium, calcium, and zinc, in the size. (The most objectionable of these substances is chloride of magnesium.)
- (4) Oxalic acid.

OIL STAINS.—These stains are caused by mineral oil coming in contact with the cloth or yarn during the spinning or weaving operations. The stains are not always apparent when the cloth is first bleached, but they generally show up on dyeing or printing.

The effect of mineral oil is to produce a pale yellow stain which resists the dyes, unless the oil be removed previous to bleaching. In spinning and weaving high-class yarns which are afterwards going to be subjected to bleaching, mineral oil should not be used for lubricating the machinery. Spermin oil is the correct oil to use, or at the very least a mixture of half spermin and half mineral oil. Oil dealers frequently offer mineral oil as “stainless.” There is no such thing as a *stainless mineral oil* if it be left on the cloth and it gets treated with “chemic.” Sometimes mineral oil stains are caused by the use of tallow which has been adulterated with mineral oil.

PARAFFIN WAX STAINS.—These stains, like those from mineral oil, are not always apparent in the bleached cloth, but they quickly show up on dyeing or printing the fabric. They may be caused by the manufacturer knowingly using paraffin wax in his size, or, as is frequently the case, by his using a tallow adulterated with mineral oil and paraffin wax. Too much care cannot be exercised in the choice of tallow for goods which have to be bleached and dyed.

Cases are known where manufacturers have used paraffin wax for years and never had a complaint of damage. A great deal depends upon the treatment of the cloth in the kiers. In some bleach works it is customary to run off the liquor from the bottom of the kier, whilst in others it is customary to force the liquor upwards so as to overflow at the top. It will be readily seen that if the former procedure be adopted there is the risk that the paraffin wax, which has melted from the cloth and floated on the surface of the liquor, will be absorbed by the top layers of the cloth as the liquor is run off, whereas by the latter method of emptying the kiers, the paraffin wax will be the first substance to be washed away. In one case the wax is removed, whilst in the other the whole of the wax from about two tons of cloth may be deposited over a portion of the cloth only, and so cause stains.

Paraffin wax stains are also caused by the weavers rubbing the yarn with this wax with a view to reducing the friction on the healds and reeds and so improve the weaving. This is a practice which should be stopped at once.

If the cloth has become stained with mineral oil, it should be removed by treating it with benzene before it is sent to be bleached, as described on page 542.

CHLORIDE OF MAGNESIUM.—Chloride of magnesium should never be used in the size employed

for goods which are intended for bleaching. This substance has been the cause of a great amount of damage at one time or another. The injury is caused to the fabric during the singeing process. The high temperature to which the cloth is subjected decomposes the chloride of magnesium with the formation of hydrochloric acid. This acid tenders the fibre, according to the severity of the singeing process and to the amount of chloride of magnesium present. In strong cloth the damage may not be apparent until the goods are dyed or printed. Then it takes the form of stains, on account of the dye being absorbed unevenly.

Many manufacturers knowingly use chloride of magnesium in the size, but there are many cases where it is used unknowingly. In the latter case its presence is due to the use of some secret preparation containing chloride of magnesium.

It has now become a generally recognised rule that the manufacturer should be made responsible for any damage which can be traced to the use of chloride of magnesium in goods which are intended for bleaching. It is only right and proper that it should be so, as there is no necessity to use such a substance for "pure sized" goods.

One reason why chloride of magnesium is used in the "size" for goods intended to be bleached is because the manufacturer is asked by the buyer to weight the yarn to the extent of 20 to 30 per

cent., and use wheaten flour instead of farina or sago.

The reason given for this is that the cloth “finishes” better if it contains flour. This matter has been fully dealt with on pages 301 to 304, to which reference should be made.

CHLORIDE OF CALCIUM AND CHLORIDE OF ZINC:—These are objectionable substances to use in the size for goods intended for bleaching, as they are liable to tender the warp when the cloth is singed.

OXALIC ACID.—This substance is used, as previously stated, for the purpose of removing “black oil” stains. It is a dangerous thing to use for cloth which has to be bleached, as it tenders the cotton fibre to a marked degree. It may also produce stains when dyed, through the formation of oxycellulose.

N.B.—This chapter is an extract from “The Chemistry and Practice of Finishing,” by Percy Bean and W. McCleary.

CHAPTER XVI.

*The Ventilation of
Humidified Weaving Sheds.*

A HUMID atmosphere is absolutely essential for the successful weaving of cotton cloth. In this respect Lancashire is particularly well situated and this is owing to its geographical position. The county has an extensive coast line on the west and it is protected by the long range of hills of the Pennine range on the east.

All winds, except those from an easterly direction, are more or less moist, especially those from the west and south-west, and this moisture is localised to a great extent to Lancashire by the Pennine range.

A glance at a physical map of England showing the rainfall will explain one reason why Lancashire is supreme so far as the cotton trade is concerned. Even Yorkshire, on the east of the Pennines, is very much drier and has a very much less rainfall than East and North-East Lancashire. It is also noticeable that those districts in Lancashire nearest the

coast, especially in the south-west, and which are farthest from the hills, are much drier than the eastern portions. For these reasons the weaving districts are found chiefly in the valleys sheltered by the Pennine range.

Another advantage possessed by Lancashire over every other cotton centre in the world is the small range of variation in the temperature between winter and summer. As will be seen from the following table the average temperature in winter is about 40° Fah., and the average in the summer is about 60° Fah.; the average temperature throughout the year being about 47° Fah.

MEAN MONTHLY TEMPERATURE OF THE OUTSIDE AIR AT
BLACKBURN AT 9 A.M. AND 9 P.M.—DEGREES FAHRENHEIT.

Month.	1900	1901	1902	1903	1904	1905	1906
January.....	37·9	36·5	37·9	37·5	37·8	37·3	39·3
February	33·8	33·7	32·5	41·5	35·3	38·5	34·5
March	36·5	37·4	40·5	42·1	37·2	42·5	38·8
April.....	45·05	45·9	44·1	42·2	45·2	42·7	44·1
May	45·6	53·1	45·6	50·8	49·2	50·3	48·9
June	56·9	58·7	55·8	52·4	54·7	55·6	53·4
July	61·3	63·7	55·09	56·9	60·03	60·3	58·4
August.....	57·1	59·1	55·5	55·2	56·6	56·6	59·5
September	55·5	55·9	53·9	54·5	54·3	52·9	56·5
October.....	47·5	47·5	47·9	48·1	48·7	47·4	49·8
November ...	45·8	40·06	43·1	42·1	41·4	39·6	43·8
December.....	43·0	36·4	38·7	36·5	37·1	40·3	35·9

The hottest months are July and August, and the coldest January and February. Even in the

coldest months the temperature rarely falls below freezing point, and in the hottest months it rarely exceeds 70° Fah. If these temperatures are compared with those of other cotton centres there will be found a marked difference. In and around Boston, U.S.A., which may be considered the Lancashire of the United States, there are extreme variations in temperature. The winter months are very cold and the summer months very hot. Extremes of temperature play an important part in the success or otherwise of the manufacture of cotton goods for the following reason:—

It has already been stated that a humid atmosphere is absolutely essential for the manufacture of cotton cloth because moisture is essential to the manipulation of cotton yarn. Cotton contains a certain amount of natural moisture and whilst any addition to this moisture increases its strength and pliability slightly, a reduction reduces the strength and pliability very greatly as the following table will show:—

TESTS OF STRENGTH OF UNSIZED COTTON YARN.
COUNTS 34'7's.

Percentage of Moisture.	Breaking Strain in ounces.	Length of Stretch in inches.	Loss of Strength.	Loss of Stretch.
6'48	6'435	1'087	.....	.....
4'41	5'000	0'772	22'3 per cent.	28'8 per cent.
2'39	4'775	0'681	25'8 " "	37'4 " "
0'45	4'780	0'650	25'7 " "	40'2 " "
Dry	4'215	0'625	34'5 " "	42'5 " "

TESTS OF STRENGTH OF YARN "SIZED"
WITH 16·5 PER CENT. OF SIZE. COUNTS 36's.

Percentage of Moisture.	Breaking Strength in ounces.	Length of Stretch in inches.	Loss of Strength.	Loss of Stretch.
10·18	7·223	0·65	.....	.....
8·02	6·550	0·569	9·4 per cent.	12·6 percent.
5·94	5·923	0·462	18·0 " "	28·8 " "
3·94	5·985	0·412	17·2 " "	36·6 " "
2·02	6·090	0·369	15·8 " "	43·1 " "
Dry	4·77	0·288	34·0 " "	55·7 " "

If cotton yarns be exposed to a dry atmosphere in the process of weaving, the air robs the cotton of its natural moisture with the result that weaving is difficult on account of the breakages which take place.

Although Lancashire possesses a climate which is even more humid than the average humidified shed as shown by the following table, and although the temperature shows only relatively small variations, this temperature is not high enough to enable work to be carried on during a great portion of the year without heating the air of the weaving shed. The effect of raising the temperature of air containing a definite amount of water is to dry the air, although the amount of water contained in it remains the same. Although it is necessary to warm the air of the weaving shed in Lancashire at certain times, it is not necessary to warm it to the same extent as it is in other countries. This is the explanation of the

statement that “the small range of variation in the temperature found in Lancashire plays an important part in the success of weaving.” At no time of the year is it necessary to raise the temperature of the outside air many degrees in order to make it comfortable for working.

A great many people are not yet clear upon this question of relative humidity and its effect on the weaving of cotton cloth, and very few people are aware that a damp or humid atmosphere may be made into a dry one by heating it. In order to make this matter clearer the following table should be carefully examined :—

TABLE SHOWING EFFECT OF HEATING A
SATURATED ATMOSPHERE FROM 33° F. TO 70° F.

	Temperature.	Relative Humidity.	Grains of moisture per cubic foot.	Grains of moisture per cubic foot required to raise the relative humidity to 82 per cent.
Outside air	33° F.	100 per cent.	2'2	.....
Same air heated to	38 "	83 "	2'2	.....
Do.	44 "	65 "	2'2	0'6 grains
Do.	49 "	55 "	2'2	1'1 "
Do.	54 "	47 "	2'2	1'7 "
Do.	60 "	37 "	2'2	2'5 "
Do.	65 "	32 "	2'2	3'4 "
Do.	70 "	27 "	2'2	4'4 "

As a further illustration take as an instance a weaving shed, 50 yards square and 5 yards high.

The air of such a shed, saturated with moisture, with a temperature at 32 degrees Fah., would contain the vapour of $11\frac{1}{2}$ gallons of water, and would, of course, feel very damp. If the temperature of the air be raised to 65 degrees Fah., and no further moisture added, the atmosphere would then feel excessively dry. From what has already been said it will be realised that the apparent dryness or dampness of an atmosphere depends not only on the absolute amount of water vapour present, but upon the temperature also. In the example above, a saturated atmosphere at 65 degrees Fah. would hold the vapour of 33 gallons of water, as against $11\frac{1}{2}$ gallons at 32 degrees Fah.

It is therefore evident that a cold atmosphere may be more humid or moist, with very little actual moisture, than a warm atmosphere which may contain a very much greater quantity of moisture. In other words, the humidity, or moistness, of an atmosphere depends not upon the absolute weight of water vapour in it but upon the degree of saturation. Therefore, if cold air be admitted to a weaving shed, the temperature of which is 65 degrees Fah., and if this air be not humidified, the following conditions would be produced :—

The cold air, whatever its condition of humidity, would rise in temperature, and would then be capable of absorbing a much greater quantity of moisture than before. This would have the effect of drying

the air in the shed, although it would still contain the same actual weight of moisture. The dry air would then begin to absorb moisture from the yarn, and from the bodies of the operatives. Putting aside the question of the operatives, this would have disastrous effects on the weaving.

It will be seen that in spite of the natural conditions possessed by Lancashire, there are many days when it is necessary to introduce moisture into the sheds, to compensate for the loss of humidity brought about by warming the air, in order to obtain good weaving. During cold weather and dry east winds weaving is difficult for reasons already given, even where the strongest yarn only is used.

The following table further illustrates the change which takes place when a change in temperature is made. In the first column a number of temperatures are given, starting at 30° Fah., and going up to 70° Fah. At each temperature the air is saturated with moisture. When the temperature is raised the percentage of saturation is lowered, because at the higher temperature the air is capable of taking up a great deal more moisture. In other words the air is rendered drier as the temperature increases. Thus if it be saturated at 30° Fah., *i.e.*, contains 100 per cent. relative humidity, and it is raised to 80° Fah. without the addition of more moisture, it would contain only 18·2 per cent. relative

humidity and in this condition it would be irritatingly dry.

Humidity of air		Humidity of the air Raised in temperature to—							
Degree.	Per cent.	Degree.	Per cent.	Degree.	Per cent.	Degree.	Per cent.	Degree.	Per cent.
30 = 100		40 = 69		50 = 48·8		60 = 34·5		70 = 25	80 = 18·2
40 = 100				50 = 70·7		60 = 50		70 = 36·3	80 = 26·4
50 = 100						60 = 70·7		70 = 51·3	80 = 37·3
60 = 100								70 = 72·5	80 = 52·7
70 = 100									80 = 72·7

Another illustration, showing the converse conditions, is the production of November fogs. November is generally a moderately warm month in the day time, with a fair amount of bright sunshine. It is also a month wherein the atmosphere is nearly at the point of saturation as regards moisture. Whilst the days are warm, the nights are usually cold. It will be noticeable that if there is a particularly bright day followed by a frosty night, dense fog occurs next day. This is brought about through lowering the temperature of a nearly saturated atmosphere, and so making it that at the lower temperature it cannot hold in solution the moisture previously contained in it.

Whilst dealing with this question of humidity it may be as well to explain clearly why east winds and cold frosty days make weaving bad.

East winds are generally set down as cold, whereas as a matter of fact they may be no colder than west winds. What is really the case is that they are dry and cause a sensation of coldness on

account of robbing the surface of the body of moisture. The rapid evaporation of moisture cools the surface of the body and produces a feeling of coldness. The same thing occurs when the dry air is sent into the weaving shed. It absorbs moisture as soon as it enters the shed and so robs the cotton of its natural moisture.

Similar conditions arise in cold frosty weather. As soon as the air enters the weaving shed it becomes warmer and then robs the fibre of its moisture.

Comparisons between the temperature and relative humidity of three humidified sheds, at that time under the management of Mr. F. Scarisbrick, and the outdoor air of Blackburn are shown for the year 1906.

1906.	The Three Humidified Sheds.		Outside Air at Blackburn.	
Month.	Average Temperature.	Relative Humidity.	Average Temperature at 9 a.m.	Relative Humidity.
January	59·2° F.	79·9%	39·3° F.	93·4%
February	56·9° F.	80·0%	34·5° F.	88·4%
March	59·5° F.	79·7%	38·8° F.	85·8%
April	62·7° F.	78·6%	44·1° F.	72·5%
May	66·5° F.	79·4%	48·9° F.	83·3%
June	73·1° F.	76·2%	53·4° F.	78·5%
July	73·1° F.	76·3%	58·4° F.	80·3%
August	74·2° F.	75·4%	59·5° F.	82·8%
September	70·5° F.	76·2%	56·5° F.	79·03%
October	66·5° F.	77·7%	49·8° F.	85·6%
November	63·0° F.	79·5%	43·8° F.	90·5%
December	58·5° F.	79·5%	35·9° F.	93·09%
Yearly Average	65·3° F.	78·2%	46·9° F.	84·43%

The three weaving sheds gave an average of 78·2 per cent., whilst the average for the outside air of Blackburn was 84·43 per cent., thus showing that the outside air is more humid, or damper, than the inside of a weaving shed where steam is introduced. It must be clearly understood that by humidity it is not intended to mean rain. The hygrometers by which the results are obtained are protected from wet weather.

It may be of interest to give a detailed list of the relative humidity of the atmosphere in Blackburn. This town is the largest weaving centre in the world where moisture is artificially introduced into the weaving sheds.

THE "MEAN" MONTHLY RELATIVE HUMIDITY OF THE
OUTSIDE AIR OF BLACKBURN.

Month.	1900	1901	1902	1903	1904	1905	1906
January.....	95·1	93·9	88·7	91·1	94·0	89·4	93·4
February	95·5	94·1	91·9	89·7	90·3	88·8	88·4
March	85·12	85·7	91·3	86·3	86·1	86·2	85·8
April	83·6	76·6	81·3	79·4	81·6	83·2	72·5
May	76·9	72·9	81·7	77·6	76·6	78·2	83·3
June	79·0	73·6	62·4	72·9	76·1	75·3	78·5
July	77·5	77·2	81·08	82·1	77·3	76·7	80·3
August	82·8	78·3	85·0	87·9	81·3	79·2	82·8
September ...	85·0	79·6	82·9	83·2	79·6	84·7	79·03
October	90·3	87·1	92·0	85·6	86·3	83·0	85·6
November ...	90·5	80·8	85·08	91·2	91·3	90·1	90·5
December.....	89·4	91·8	89·5	90·9	91·5	91·1	93·09
Yearly Average	85·9	82·6	84·4	84·8	84·3	83·8	84·4

Whilst dealing with the question of relative humidity it might be as well to show by some comparison what is meant by the terms “damp” and “dry.”

Air containing 90% to 100% relative humidity is very damp.

80 " " 90 " " " damp.

„ „ 70 „ „ 80 „ „ „ neither damp nor dry.

„ „ 60 „ „ 70 „ „ „ is dry.

„ „ 50 „ „ 60 „ „ „ „ very dry.

“ “ less than 50% is uncomfortably dry.

The average relative humidity throughout the British Isles is about 80%.

From these explanations it must be apparent that in order to carry on the business of cotton manufacturing the air of the weaving shed must be "conditioned" in order to keep it at a regular temperature and in a regular state of humidity.

Without desiring to enter into the controversial side of the question of "steaming" the authors firmly believe that a weaving shed where "steaming" is carried on, and which is suitably ventilated, is a far healthier workshop than any of the so-called "dry sheds" which are not humidified and which are not ventilated by power. This opinion is strongly supported in the report published by the Chief Inspector for Factories in 1905. It is not suggested that "steaming" is a direct benefit to health by any means. The opinion is based upon the vastly improved conditions obtained through the ventilation of such workshops. These conditions do not, and

cannot exist in non-steaming places if weaving has to be carried on at all.

A moderate percentage of moisture at moderate temperatures in well ventilated sheds is far less harmful than the presence of "air sewage" in a "dry" but badly ventilated shed. It is only when the wet bulb temperature is high that unhealthy and disagreeable conditions arise.

The operatives have more to gain in health and comfort by insisting upon a good atmosphere to work in, *i.e.*, one in which the amount of organic matter is low, than by agitating for the total abolition of "steaming." They would have had reasonable grounds for complaint had not the question of ventilation been raised, and the conditions of the atmosphere greatly improved.

In order to protect the weaver against humid conditions at high temperatures a schedule was drawn up and incorporated in the Cotton Cloth Factories Act. If the temperatures and limits of humidity are examined in this table (shown on page 601), it will be noticed that as the temperature rises there is a decrease in the percentage of humidity allowed. Since this table was arranged by the authorities it has been found out that the depressing effects produced by working in a warm moist atmosphere are more accurately determined by the temperature of the "wet bulb" thermometer than by the percentage of humidity.

Instead of any alteration taking the form of lowering the percentage of humidity at high temperatures there is every probability that a maximum "wet bulb" temperature will be fixed for cotton cloth factories. The depressing effects of high "wet bulb" temperatures, and the accompanying rise of body temperatures, are most marked in persons who are not acclimatised to these conditions. Those who are accustomed to working under certain conditions become "seasoned" to them, whereas strangers to a warm moist atmosphere will suffer much greater discomfort, and this must be taken into consideration by those who investigate these matters.

At the same time there is no doubt that an atmosphere having a high "wet bulb" temperature produces bodily discomfort. The temperatures at which this feeling of discomfort begins depends to a certain extent upon the amount of air movement which accompanies the "wet bulb" temperature. A higher temperature can be borne where there is plenty of ventilation than where the air is stagnant.

As previously stated people accustomed to certain conditions become acclimatised to them, and there will be less rise in body temperature with those people than with people who are strangers to the conditions. It is not possible to say what are the physiological effects of working in an atmosphere which produces a rise of body temperature. One

thing is certain and that is, the effects cannot be beneficial.

With a view to obtaining some practical information on the effects of working in an atmosphere having a high "wet bulb" temperature a series of experiments were undertaken by Mr. Fred Scarisbrick, under the guidance and control of Dr. Howarth, Medical Officer of Health for Darwen.

These experiments, the results of which are given in the following tables, consisted of climbing a ladder, three feet high, a certain number of times a minute. At intervals of ten minutes the mouth temperature was taken, and the results, with any observations, were noted by Dr. Howarth. The experiments were conducted in a room specially arranged for the purpose. The temperature and the degree of humidity were under control, but there was no system of ventilation installed, and this was the only difference between the room and a humidified weaving shed.

In order to compare the effects produced on Mr. Scarisbrick with the effects on the weavers in the shed, who were working in similar temperatures (this day was the hottest day of the year), the "mouth temperatures" of a number of weavers were taken. These are shown in the table on page 600. It is noteworthy that the "mouth temperatures" of the operatives were lower, at the same "wet bulb"

temperature, than was shown by Mr. Fred Scarisbrick in his three series of experiments. This may have been due to the fact that the weaving shed was much better ventilated than the room in which the ladder climbing experiments were conducted, or it may have been due to the operatives being more "seasoned" to a humid atmosphere and to performing less work in a given time.

EXPERIMENTS MADE AT GEORGE STREET MILLS.
A LADDER, 3 FEET HIGH, WAS CLIMBED TWICE
A MINUTE. MARCH 10TH, 1908.

Time.	Temperature of Dry Bulb.	Temperature of Wet Bulb.	Mouth Tem- perature.	Observations.
3-15	85.0°F.	78.0°F.	98.5	slight perspiration. profuse "
3-25	85.0 "	79.5 "	99.1	
3-35	84.8 "	79.0 "	99.2	
3-45	84.7 "	79.3 "	99.3	" "
3-55	84.8 "	79.6 "	99.2	" "
4-5	84.8 "	78.5 "	99.2	" "
4-15	83.8 "	78.0 "	99.3	" "
4-25	84.5 "	79.2 "	99.3	" "
4-35	85.0 "	79.8 "	99.3	" "
4-45	84.7 "	79.7 "	99.2	" "
4-55	85.0 "	80.0 "	99.2	" "
5-5	86.0 "	80.2 "	99.2	" "
5-15	85.5 "	79.0 "	99.4	turned on more steam in order to raise the wet bulb temperature.
5-20	85.5 "	82.0 "		
5-25	86.0 "	83.0 "	99.6	turned off steam.
5-30	86.0 "	76.5 "	99.4	stopped exercising.
6-0	83.0 "	75.0 "	99.2	

It will be noticed that the "mouth temperature," shown in the experiments given on page 598, only rose from 98·5° Fah. to 99·4° Fah. in the two hours' work from 3-15 p.m. to 5-15 p.m., in an atmosphere having a "wet bulb" temperature ranging from 78° Fah. to 80·2° Fah., but when the "wet bulb" temperature was increased at 5-30 p.m., the mouth temperature quickly rose to 99·6° Fah.

A LADDER, 3 FEET HIGH, WAS CLIMBED 3 TIMES
A MINUTE. MARCH 17TH, 1908.

Time.	Temperature of Dry Bulb.	Temperature of Wet Bulb.	Mouth Tem- perature.	Observations.
3-20	87·0°F.	79·5°F.	98·6	
3-30	86·0 "	79·0 "	99·2	
3-40	85·0 "	78·0 "	99·5	perspiring
3-50	85·7 "	79·0 "	99·4	"
4-0	85·2 "	78·5 "	99·6	"
4-10	86·0 "	80·0 "	99·7	heavy perspiration
4-20	86·0 "	79·2 "	99·8	" "
4-30	85·8 "	78·8 "	99·6	" "
4-40	85·6 "	78·2 "	99·7	" "
4-50	86·0 "	79·2 "	99·8	" "
5-0	85·8 "	79·2 "	99·7	" "
5-10	85·7 "	79·1 "	99·8	" "
5-20	85·0 "	77·7 "	100·0	" "

In this experiment there was a rise of 1·4° Fah. in the "mouth temperature" after two hours' heavy work in an atmosphere having a "wet bulb" temperature ranging from 78° Fah. to 80° Fah.

A LADDER, 3 FEET HIGH, WAS CLIMBED 4 TIMES
A MINUTE. MARCH 19TH, 1908.

Time.	Temperature of Dry Bulb.	Temperature of Wet Bulb.	Mouth Tem- perature.	Observations.
4-0	86·5°F.	79·5°F.	98·0	
4-10	87·0 „	79·0 „	98·9	perspiring.
4-20	87·0 „	78·0 „	99·1	„
4-30	87·5 „	79·0 „	99·2	heavy perspiration.
4-40	88·0 „	80·0 „	99·4	„ „
4-50	88·0 „	79·0 „	99·6	„ „
5-0	88·0 „	79·0 „	99·6	„ „
5-10	88·0 „	80·0 „	99·8	„ „
5-20	88·2 „	79·2 „	99·8	„ „
5-30	88·0 „	77·5 „	99·8	

TEMPERATURES OF HYGROMETERS AND MOUTH
TEMPERATURES OF WEAVERS IN TOWNSFIELD SHED.
JULY 2ND, 1908.

Time.	Temp. of Dry Bulb.	Temp. of Wet Bulb.	Weaver's Number.	Description of Weaver.	Temp. of Mouth.
3-45	88·0°F.	79·5°F.	366	middle aged man	98·6
4-0	88·0 „	79·5 „	394	young woman	98·6
4-50	88·0 „	79·5 „	444	girl 13 years	99·0
4-55	88·0 „	79·5 „	474	young woman	98·7
5-0	88·0 „	79·5 „	248	man	98·4
5-5	88·0 „	79·5 „	324	young woman	98·5
5-10	88·5 „	79·5 „	284	young man	99·0
5-15	88·5 „	79·5 „	350	half-timer 12 yrs	98·6

All the above worked in the centre of the shed near the hygrometer and were picked haphazard.

MAXIMUM LIMITS OF HUMIDITY OF ATMOSPHERE
AT GIVEN TEMPERATURES.

I. Grains of Vapour per Cubic Foot of Air.	II. Dry Bulb Thermometer Readings. Degrees Fahr.	III. Wet Bulb Thermometer Readings. Degrees Fahr.	IV. Percentage of Humidity. Saturation=100.
1'9	35	33	80
2'0	36	34	82
2'1	37	35	83
2'2	38	36	83
2'3	39	37	84
2'4	40	38	84
2'5	41	39	84
2'6	42	40	84
2'7	43	41	84
2'8	44	42	84
2'9	45	43	85
3'1	46	44	86
3'2	47	45	86
3'3	48	46	86
3'4	49	47	86
3'5	50	48	86
3'6	51	49	86
3'8	52	50	86
3'9	53	51	86
4'1	54	52	86
4'2	55	53	87
4'4	56	54	87
4'5	57	55	87
4'7	58	56	87
4'9	59	57	88
5'1	60	58	88
5'2	61	59	88
5'4	62	60	88
5'6	63	61	88
5'8	64	62	88
6'0	65	63	88
6'2	66	64	88
6'4	67	65	88
6'6	68	66	88
6'9	69	67	88
7'1	70	68	88
7'1	71	68'5	85'5
7'1	72	69	84
7'4	73	70	84
7'4	74	70'5	81'5
7'65	75	71'5	81'5
7'7	76	72	79

MAXIMUM LIMITS OF HUMIDITY OF ATMOSPHERE
AT GIVEN TEMPERATURES
(Continued).

I. Grains of Vapour per Cubic Foot of Air.	II. Dry Bulb Thermometer Readings. Degrees Fahr.	III. Wet Bulb Thermometer Readings. Degrees Fahr.	IV. Percentage of Humidity. Saturation=100.
8.0	77	73	79
8.0	78	73.5	77
8.25	79	74.5	77.5
8.55	80	75.5	77.5
8.6	81	76	76
8.65	82	76.5	74
8.85	83	77.5	74
8.9	84	78	72
9.2	85	79	72
9.5	86	80	72
9.55	87	80.5	71
9.9	88	81.5	71
10.25	89	82.5	71
10.3	90	83	69
10.35	91	83.5	68
10.7	92	84.5	68
11.0	93	85.5	68
11.1	94	86	66
11.5	95	87	66
11.8	96	88	66
11.9	97	88.5	65.5
12.0	98	89	64
12.3	99	90	64
12.7	100	91	64

VENTILATION.

Ventilation is the science of removing vitiated air from a building, and circulating fresh air without creating draughts.

There are two principles of ventilation, viz.: the natural or extraction principle, and the pressure or plenum principle. All systems of ventilation are modifications and adaptations of these two principles.

EXTRACTION PRINCIPLE.

Ventilation by extraction may be carried out by means of fans, or by allowing the vitiated air to escape through openings at the ceiling made for the purpose. The air thus removed is replaced by air entering at a lower level.

Until recent years all ventilation was carried out on the extraction principle because it was the easiest to adapt to the general run of buildings.

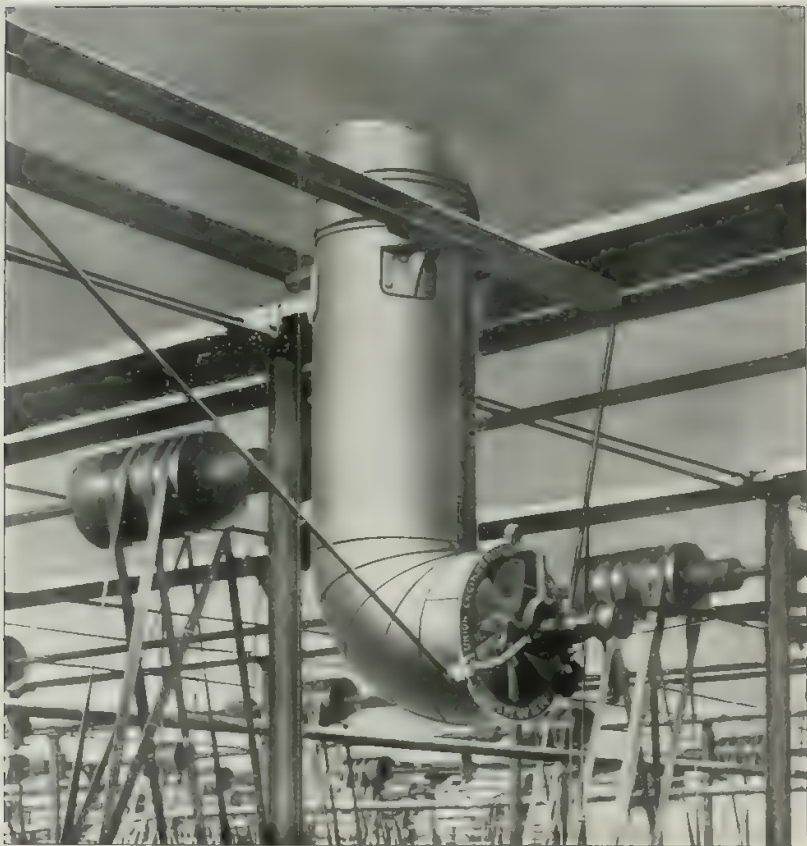
The extraction principle by means of fans as applied to weaving sheds has many advantages if properly carried out. The fans are easily fixed and, as there is no heating apparatus attached to the trunks, there is practically nothing to get out of order.

Unfortunately the science of mill ventilation has been little understood in the past, and in consequence ventilation by extraction fell into ill repute because it failed at the time to bring weaving sheds within the "Act." One idea seems to have possessed all engaged in ventilation, and that was to place the extraction fans as high up as possible. In a weaving shed this is fatal to success, because the only places ventilated by this arrangement would be the bays in the roof, from the gulléy to the top of the glass.

By lowering the point of extraction the air which enters the shed to replace that which has been removed is better diffused at the breathing height than would be possible by having the fans high up.

An instance of this was shown in a certain notable case in which the Factory Inspector prosecuted under the "ventilation clause" of the Cotton Cloth Factories Act. He lost his case on a technical point, but the firm of manufacturers feared an appeal, and called in the writer to suggest some means by which the shed could be put right.

The amount of air passing out of the fan trunks was measured, and it was found that there were more fans being used than were necessary to bring the shed well within the Act. The fans were fixed to trunks which came through the slates for a distance of about three feet. These trunks were bent at right angles, thus causing the fans to face the glass roof. What possessed an engineer to place them in this position, at this height, is beyond the imagination. It is, or should be a well-known fact that a large bulk of the air drawn in by all extraction fans in weaving sheds comes through the slates and plaster, and through crevices at the bottom of the glass. Therefore, if the fans are placed near the roof, fresh air is drawn into the shed and immediately extracted at the roof before it has reached the breathing height. The writer saw at once that the shed contained more than a sufficient number of fans to move the required volume of air but that it was not being properly distributed. In order to bring this about he arranged to have the trunks containing the fans



Ventilating Apparatus showing Vertical "drive" of Extraction Fan.

The Union Engineering Co , Darwen.

Plate XIX.

lengthened so that they reached to about eight feet from the floor level. The air was afterwards analysed and found to contain nearly 50 per cent. less carbon dioxide than before. Lengthening the trunks caused the air to be circulated at a much lower level than before. Not only was this most important advantage secured, but the fans had far greater power to act upon the air immediately breathed by the operatives, because the points of extraction were so much nearer to the breathing height. As a matter of fact the improvement was entirely due to the fresh air being diffused throughout the weaving shed instead of being immediately removed before it had any effect.

Lengthening the trunks, as described above, is not a scientific way of overcoming the difficulties of extracting at a low level. In the first place there is the disadvantage of having the strap working through a hole in the trunk. In the second place it is difficult to adjust the strap when necessary, and there is a difficulty in lubricating the various parts. The fan is also in an awkward position for cleaning.

It has often occurred to the authors that if the fans could be arranged so as to be driven at any height not exceeding 7 feet 6 inch to 9 feet from the floor one of the greatest objections to ventilation by means of extraction would be overcome. This can be done by using a trunk which is bent at right angles, so that the fan works vertically instead

of horizontally. The Union Engineering Co. of Darwen, have applied this principal most successfully. The fan constructed by this firm has a specially long spindle on the fan pulley to withstand the strain of driving. When the fans are fixed in the way described there is no half twist in the strap, and there is no difficulty, such as is usually experienced with extraction fans, of keeping the strap on. The fans can be cleaned and lubricated with the minimum amount of trouble. An illustration of the arrangement is shown on *plate xix*.

In spite of the fact that the extraction principle has many advantages when rightly applied, there are a number of objections to it. In the first place there is no control of the source from which the air may come. It may be drawn from closets, and other objectionable places, whereas under the plenum principle the air is forced into the shed from definite positions. (In modern weaving sheds the above objections do not exist because closets are not attached to the buildings). In the second place extraction fans often cause draughts near the doors or other large inlets in the shed. This is not only objectionable as far as the weaver is concerned, but it often produces bad weaving places. This objection however, can be overcome by a little skill in arrangement.

The extraction principle is more suitable for small sheds (not exceeding about 300 or 500 looms), than it is for large sheds. The reason for this is

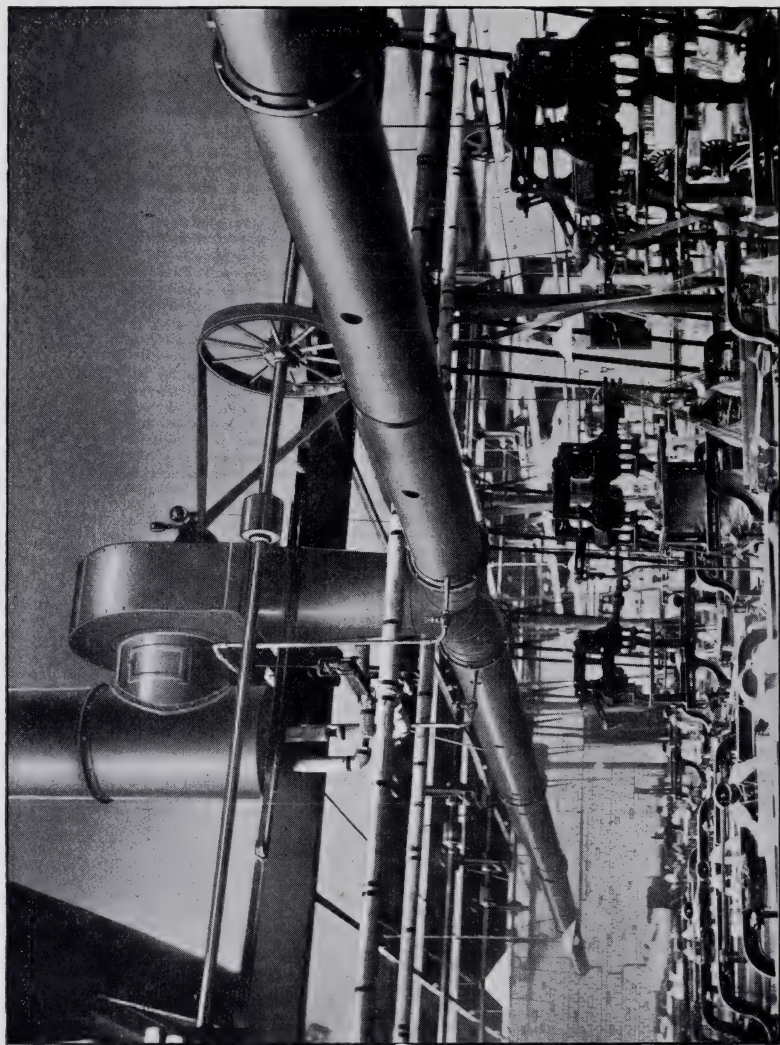


Plate XX.—“Cyclone” Humidifying and Ventilating Apparatus.

By Matthews & Yates Ltd., Swinton, Manchester.

that a large proportion of the air comes through the walls and doorways, and if this air has to travel a considerable distance before it is extracted, it will become more contaminated than if it has to travel a shorter distance.

Under the extraction system a large weaving shed may vary according to the outside conditions. If the wind blows from the east the shed will be found to contain more carbon dioxide on the west side, and *vice-versa*, and, unless a large shed be over-ventilated it is difficult to keep all parts of it within the "Act." The plenum system is, of course, independent of winds, because the pressure comes from within and not from without.

PLENUM PRINCIPLE.

At the present time the plenum principle is the most popular amongst ventilating engineers, and there are many reasons for this.

In the first place the fresh air is forced into the weaving shed from definite positions. This prevents foul air from closets, fermenting rooms, and other objectionable places, getting into the shed.

In the second place the air can be filtered, and also "conditioned," before it enters the shed.

In the third place the air is warmed before it enters the shed, and there is no danger of cold air affecting either the operative or the weaving.

Wherever the plenum principle is employed it is essential that a "steaming" or "conditioning" apparatus should be attached to it, otherwise it will spoil the weaving. In a great many cases the plenum system has been adopted in sheds already fitted with steam jets. In these cases there is not the same necessity to humidify the air as it enters, but it would be better if it were done.

The plenum principle is applied in various ways by ventilating engineers. Some use centrifugal fans or "pressure blowers," others reverse the ordinary type of fan and force air into the shed instead of extracting it. Some engineers force the air through a series of air ducts, either by means of a steam jet or by means of a "pressure blower." A short description of the principal types of ventilating systems may be of interest.

Amongst the principal firms who have successfully dealt with the ventilation of weaving sheds under the plenum system may be mentioned, Matthews & Yates Ltd., Swinton; James Howorth & Co. Ltd., Farnworth; the Union Engineering Co. Darwen; and Messrs. Thomas Gregson, Great Harwood.

A simple form of ventilating apparatus, on the plenum principle, is made by Messrs. Thomas Gregson, of Great Harwood. This apparatus contains a heating coil for warming the air, but it has no humidifying attachment.

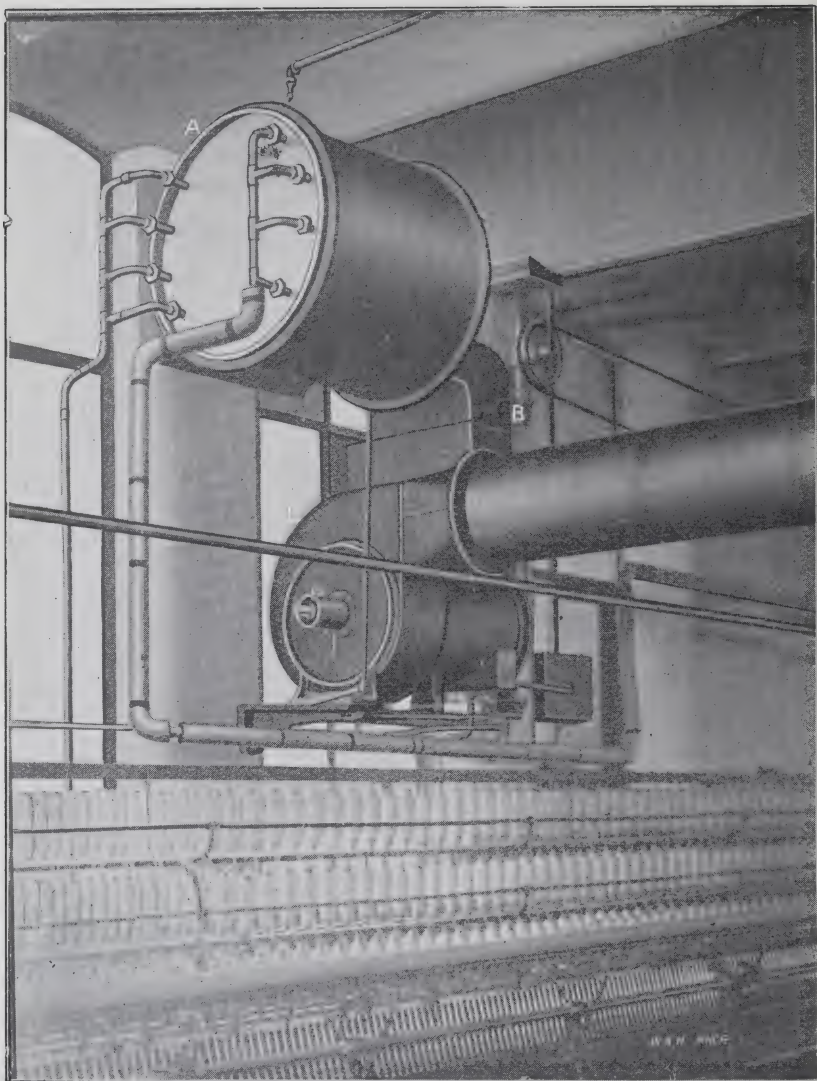
A distinctly different type of ventilating and humidifying apparatus, whereby the air is forced through a system of air ducts or trunks, is made by Messrs. Matthews & Yates Ltd., of Swinton, and Messrs. James Howorth & Co. Ltd., Farnworth. Both systems are successful ventilating appliances and they leave little or nothing to be desired so far as humidification is concerned. Both systems are suitable for spinning mills as well as weaving sheds.

An illustration of the apparatus of Messrs. Matthews & Yates Ltd. is shown on *plate xx*, and that of Messrs. James Howorth & Co. Ltd. on page 610 and *plate xxi*.

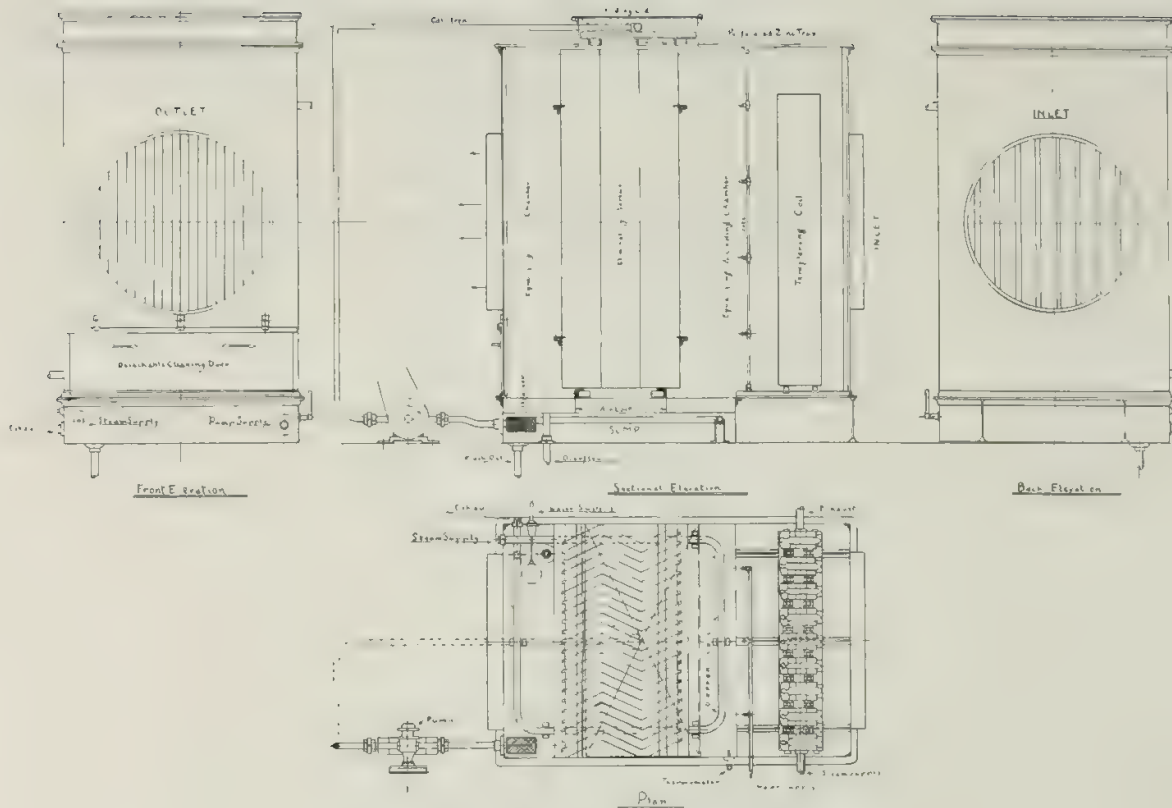
VENTILATION OF SPINNING MILLS.

Spinning mills present considerable difficulties in the way of successful ventilation. To reduce the amount of carbon dioxide is an easy matter, but to produce suitable conditions for spinning is not so easy.

For successful spinning the air must be moist, but not too moist. If it be too dry the yarn is weakened, and spinning becomes difficult, with resulting bad yarn. On the other hand, if the moisture be in too great quantity, there is trouble with the roller laps, and a very considerable danger of the finer parts of the spinning machinery and the rollers rusting, a condition absolutely fatal to spinning.



Humidifying and Ventilating Apparatus.
James Howorth & Co. Ltd.; Farnworth.



Design A. Illustrating large type used where floor space is available

Plate XXI.—"Champion" No. 2. Humidifier and Air Washer
James Howorth & Co Ltd., Farnworth

Again, on certain days, unless the air be filtered, the yarn would be blackened and rendered unsaleable.

At the present time the majority of spinning mills are ventilated by means of windows which may be opened or closed at the will of the particular operatives working near them. The writer has taken samples of air from a large number of spinning mills, and from the information obtained by analysis the following conclusions were arrived at:—

1st.—That a large air space in a spinning room is not necessarily a condition for successful ventilation.

2nd.—That to obtain a condition approaching the standard laid down for humidified weaving sheds it will be necessary to employ mechanical power.

The reason why a large air space is not sufficient is in itself explained by the working conditions of the spinning rooms. The temperature of the air is very frequently over 90 degrees Fah., even in winter; consequently the air expired from the lungs is no warmer, or lighter, than the mill atmosphere, and thus has little tendency to rise. In an ordinary building, heated to 60 or 70 degrees Fah., the air given off from the lungs is 25 to 35 degrees higher, and consequently much lighter. In the spinning rooms it is simply a case of stagnation.

APPENDIX A.

*Flour Milling,**with**Farina and Dextrin commercially considered.*

IN a work of this kind it is not necessary to go exhaustively into the making of flour in ancient times, suffice it to say that until about thirty years ago the process consisted principally of the scouring of the wheats through wire gauze sieves, some flat and other cylindrical, and the reduction of the cleaned wheat to flour, and to various sizes of bran, by grinding between horizontal mill-stones, specially cut or grooved so as to have a shearing action on the wheat, and as little attrition on the interior of the wheat berry as possible.

An exception to this method of manufacture must, however, be made in favour of Hungary. In that country, a variety of wheat is grown which is exceedingly rich in gluten, but is so hard that to grind by mill-stones reduced the whole to a sharp

powder, the branny coat of the wheat being inextricably mixed with the floury particles, and a flour produced both unsightly in appearance and unpleasant in flavour and texture. Thus, out of the richest wheat in the world, one of the poorest flours was produced. The Hungarian millers, however, gradually evolved a new system of treatment of the grain by reducing it by gentle breaking up between grooved rollers. This process of reduction was repeated five or six times, the first reduction opened the wheat, and shook the interior of the grain, dislodging large particles. These were then sorted by horizontal sieves, and each division subjected to air currents drawn through the semolina as it fell from stage to stage. At each reduction these processes were repeated, until at last the wheat was divided into various sizes of granular semolina (resembling various grades of sugar) on the one hand, and various grades of wheat offals (such as bran, coarse and fine sharps, and the germ of the wheat) on the other. For a time, the purified semolina was reduced to flour by mill-stones, but their action destroyed the granular character of the flour, and they were discarded in favour of smooth rollers capable of the nicest regulation. In this manner, the finest flour in the world was produced, a flour which has never been surpassed, and which for a long time was not even distantly approached by any other.

Austrian, or more correctly Hungarian, flour gained a world-wide fame, the mills at Buda-Pesth, and other places on the Danube, were gigantic in size, beautiful in structure, and exceedingly prosperous commercially. But the old adage, "Pride goes before a fall," came true here as in so many other instances, for, in the fulness of their heart, they opened their doors and exhibited all their processes to a large excursion of millers and milling experts, organised by an eminent English milling engineer, and this party, including as it did, the brightest men of Great Britain and America, mastered on the spot the whole system of Hungarian milling. The next thing was to apply their knowledge to the wheats they were themselves treating. These, it is true, differed in many cases from Hungarian, but were still workable on that system.

The Americans were the first in the field with their modified system, quickly followed by England, and within ten years, the Hungarian methods had been so simplified, the construction of the machines so improved, and the processes rendered so completely automatic that many of the largest Austrian mills were re-constructed entirely by English engineers. The North-west of America, including the United States and Canada, produces wheat closely resembling the hard Hungarian, and of this immense district, Minneapolis, in Minnesota, is the

centre. There has been created a milling industry equal to, and parallel with, that of Buda-Pesth. The huge mills there are driven entirely by water, a large canal above the falls of St. Paul taking sufficient water for all the mechanical processes required by the city for both milling and electrical purposes.

But, besides the gradual reduction of the wheat by roller processes, there have gone on alongside it other improvements in the cleaning and conditioning of the wheat, of almost equal importance. As before stated, the instruments used for the cleaning of the wheat were primarily two:—

THE SIEVE OR SCREEN, AND FAN.

These were, however, of little use in dealing with the various wheats dumped on the British markets from India, Syria, Egypt, Chili, the Argentine, &c., for it is a notable fact that, wherever the Anglo-Saxon has settled, from that country comes clean wheat, unmixed with soil or stones, thus all North-American, Australian, New Zealand, or our native wheats, come to market comparatively pure and clean, whilst from Kurachee we get 10 per cent. of fine grey sandy mud deposited by the Indus, from Bombay we get from 5 to 15 per cent. of sticky black clay, from Jubbulpore small stones, from Calcutta all kinds of mineral impurities, from Syria, small stones and bits of iron ore, from Egypt the Nile

mud is largely sent with both wheat and beans, and from Chili some of the wheats evidently trodden out by oxen are gathered from the quartzly threshing-floor, and our teeth set on edge by eating bread as gritty as if so much ground glass had been added to the flour.

The difficulty the English miller has had to face is therefore a very great one; it is, how to produce an article paramount of importance, both as to regularity of colour, flavour, cleanliness, and glutinous strength, out of materials so diverse in colour and hardness, and so loaded with impurities. Different classes of wheat may also at one time glut the market, whilst at another they may completely disappear, in some cases for years together. It is the necessity of so blending and treating these varieties of wheat as they successively arrive, and of making the business commercially successful, that has rendered British milling one of the most anxious and unremunerative of our trades, and one which constantly racks the minds of millers, managers, and experts. For we must remember that in this article it is not the analytical chemist and the manufacturer alone whom the miller has to satisfy, but the whole population are daily, nay incessantly, testing his products by the infallible processes of mastication, taste, smell, and digestion, and all his judges from childhood to old age, are capable of forming and expressing a sound opinion on the matter.

WHEAT CLEANING AND CONDITIONING.—The first process in the cleaning of wheat is to free it from such impurities as straws, stones, lumps of dirt, &c. For this purpose it is put through a separator and scourer. The separator consists of a series of three sieves placed one above the other, and moving to and from at a very rapid rate, the sieves being inclined at about 33 degrees. This shaking action and inclination keeps the grain moving rapidly downwards. The sieves are usually of perforated zinc or steel, the top sieve removes sticks, straws, lumps of dirt, stones, &c., which are *larger* than a grain of wheat, and delivers them to the rubbish bag. The wheat then passes over another perforated plate with holes sufficiently large to allow everything *smaller* than a grain of wheat to pass through, and thus the wheat is cleared of dust, small seeds, and pellets of clay and earth.

The wheat then proceeds to a steel cylinder perforated as in the previous case but provided with beaters or brushes run at a great speed, and by scouring and attrition some of the remaining particles of earth are removed by fans, and carried to the dust-collectors or stive rooms.

Of late years the great importance of absolutely clean wheat has induced most millers to wash their wheats. Some wheats, such as English, Californian, Australian, and American winter, are sufficiently clean without, but almost all others, both on account

of their extreme hardness and also because they come so dirty, require washing. This is done after cleaning as before described. Some wheats require very rapid treatment, being simply rushed through the water by centrifugal action, but others require longer immersion. Both are however, after washing, carried to a wheat whizzer, a machine very similar in principle and action to the hydro-extractors used by printers, bleachers, and dyers, to clear their cloth or yarn of superfluous moisture.

The wheats are afterwards blended, and, after lying together for some time to assimilate, are passed through a drying or tempering process. This consists in allowing the wheat to proceed down the outside of a cylindrical or a square tube covered both inside and out with perforated metal, or with wire gauze. Through the wheat, which is constantly descending by its own weight, is driven by fans, a stream of hot dry air, prepared in special chambers filled with coils of copper tubes constantly heated by steam, and thus the whole mass to be treated becomes of one uniform degree of hardness and is at once ready to be broken up by the roller mills as already described.

Having described in a general way the evolution of modern methods of corn milling, we must now devote a short space to the consideration of our wheat supplies.

The subjoined table gives the percentage of our wheat imports from the chief sources of supply during the last quinquennium:—

COUNTRY.	1900. per cent.	1901. per cent.	1902. per cent.	1903. per cent.	1904. per cent.
Argentina	19'0	8'2	4'2	12'2	18'5
Roumania	0'8	0'5	2'2	2'7	1'3
Russia	4'6	2'5	6'1	14'8	20'1
United States	58'2	66'2	60'2	40'0	15'7
Other Foreign Countries...	5'1	3'3	3'7	3'3	5'2
Total Foreign Countries ...	87'7	80'7	76'4	73'0	60'8
Australia	3'0	6'1	3'9	.....	9'6
Canada	8'1	8'5	11'3	12'4	7'6
India.....	.....	3'3	8'2	14'6	21'6
Other British Possessions	1'2	1'4	0'2	... ..	0'4
Total British possessions...	12'3	19'3	23'6	27'0	39'2

Roughly speaking it may be stated that our total wheat (and flour) imports are equal to about three times the quantity of wheat *grown* in the United Kingdom and that the proportion of imported to home-grown grain shows a tendency to increase. As will have been noticed from the above statistics the United States in 1904 lost its pre-eminence among our contributories and sank to the fourth place on the list, whilst India rose to the first place (supplying 25'5 million cwts. out of 118 million cwts.), closely followed by Russia and Argentina, with 23'7 and 21'8 million cwts.

respectively. Australia also in 1904 sent the largest quantity received thence up to that time (11·3 million cwts.), as against practically nil in 1903.

Taking the last four seasons the wheat-importing countries of the world require some 64 or 65 million quarters of wheat per annum, of which about 26 or 27 millions are required by the United Kingdom, about 8 or 9 millions by Germany, 6 by Belgium, and 4 to 6 by Italy. Against these world's requirements may be set the following surpluses:—

	1905-6.	1904-5.	1903-4.
(In thousands of quarters—1 qr=480 lbs.)			
Russian and Danubian Countries...	30,000	29,000	24,500
U.S.A.....	12,500	5,500	14,325
Canada	5,250	2,750	3,250
Argentina	13,000	13,000	9,500
India	3,250	9,500	7,200
Australasia	4,000	4,500	3,500
Miscellaneous.....	1,000	1,450	1,850
Total.....	69,000	65,700	64,125

Of the above wheat-exporting countries it may be mentioned that the Australasian crop (while excellent in quality) is only a small one, though gradually improving in this respect:—1899, 5,500; 1900, 6,900; 1901, 5,400; 1902, 2,500 (famine year); 1903, 10,100; 1904, 7,900; 1905, 9,500; 1906, 9,000 (estimated) thousands of quarters.

The Argentine crop is a large one and may in time become immense, as there are wheat lands

gently sloping to the Parana and other rivers, capable of producing, under good cultivation, enough wheat for the whole human race, whilst the rivers are open for 1,500 miles inland for vessels capable of carrying 800 tons. This crop has fairly constantly increased, and when a good one, is an important factor in preventing prices running away at a critical period of the cereal year (February, March and April), when also India and Australia are helping to relieve the situation.

The following table (taken, as are many of the statistics quoted, from the "Statist") giving the totals of Argentine wheat crops and exports for the past few years is interesting :—

1899	.....	12,750,000 qrs.	...	9,750,000 qrs.
1900	.....	8,250,000 qrs.	...	4,150,000 qrs.
1901	.....	7,000,000 qrs.	...	3,000,000 qrs.
1902	.....	12,500,000 qrs.	...	8,000,000 qrs.
1903	.....	15,500,000 qrs.	...	11,250,000 qrs.
1904	.....	18,500,000 qrs.	...	13,000,000 qrs.
1905	.....	16,500,000 qrs.	...	13,000,000 qrs.
				(1 qr. = 480 lbs.)
1906	.....	16,500,000 qrs.	(estimated).	

The average world's wheat crop for the last four years, 1903-1906, has been about 417 million qrs. and of this quantity U.S.A. has produced 80, Russia (alone) 77, France, 42, India, 39, Hungary (including Slavonia and Croatia) $21\frac{1}{2}$, Italy $19\frac{3}{4}$, Germany $17\frac{1}{4}$, Argentina $16\frac{3}{4}$, Spain $12\frac{1}{2}$, Canada $11\frac{1}{2}$, Roumania $10\frac{1}{2}$, Japan $10\frac{1}{4}$, Australia 9, United Kingdom $6\frac{1}{4}$, million quarters respectively on an average.

The wheat crops are reaped as early as the end of May in Kansas and Texas, and as late as October in the new North-western States and N.W. Canada. The Russian and European crops generally are reaped, like our own, from the beginning of July to the end of September. Many of the Northern States of America, Canada, and Russia, have, from April to the beginning of July, two crops of wheat growing side by side. First, the *Winter wheat* sown the previous autumn and well advanced when spring arrives; and secondly, the *Spring wheat*, which is cultivated in the colder districts and cannot withstand the rigour of the winter. The latter is not sown, therefore, till the frost is out of the ground, say about the middle of April, and cannot mature till late in the season. The danger to this crop arises from premature frosts before the wheat is ripe, a single night sometimes ruining the most brilliant prospects. The average relative weights of these crops in America are as three of Winter to two of Spring wheat.

After the harvest farmers naturally desire to market their produce quickly for monetary reasons, and especially so in Russia and the northern parts of America, because the rivers, lakes, and the Black and Baltic seas are often closed by ice from about the middle of November to the following April. Thus the wheat which is intended to be sold is rushed to market from all quarters during September

and October, and often, as a consequence, in or about October the lowest price is reached for the whole cereal year.

After October the shipments from Argentina, India and Australia are dwindling away and for a period of about three or four months the world's market is left in the hands of Russia (with Roumania) and America (with Canada). From February onwards the newly-reaped Argentine, Australian and Indian crops come round again, and by their relative abundance or deficiency modify the situation until July or August. About this period we are favoured with estimates of the various wheat crops reaped or about to be reaped in Europe and America, and also with the estimated acreage sown once more in Australia, Argentina and India. It is therefore generally possible by about the middle of September to forecast approximately what will be the world's surpluses and requirements during the ensuing twelve months and to form a fairly accurate idea as to the general trend of prices during the new campaign.

As by about this time or a little later (say the middle of October), the size and quality of the potato crops of Europe are known and tested, and the manufacture of the latter into farina is then in full progress, in order that that article may also be got to the seaboard before the close of inland navigation, October is the most favourable period of

the year for manufacturers, bleachers, and printers to contract for their yearly requirements.

The "NORTH WESTERN MILLER" gives the following as a list of the months of harvest in the chief wheat-growing areas:—

January....Australia, New Zealand, Chili, and Argentine.

February and March.—East India and Upper Egypt.

AprilLower Egypt, Syria, Cyprus, Persia, Asia Minor, India, Mexico, and Cuba.

MayAlgeria, Central Asia, China, Japan, Morocco, Texas, and Florida.

June.....Turkey, Greece, Italy, Spain, Portugal, S. France, California, Oregon, Louisiana, Mississippi, Alabama, Georgia, Carolina, Tennessee, Virginia, Kentucky, Kansas, Arkansas, Utah, Colorado, and Missouri.

JulyRoumania, Bulgaria, Austra-Hungary, South of Russia, Germany, Switzerland, France, South of England, Nebraska, Minnesota, Wisconsin, Iowa, Illinois, Indiana, Michigan, Ohio, New York, New England and Upper Canada.

AugustBelgium, Holland, Great Britain, Denmark, Poland, Lower Canada, Columbia, and Manitoba.

September and October.—Scotland, Sweden, Norway and North of Russia.

November...Peru, and South Africa.

December...Burmah.

FARINA AND DEXTRIN

COMMERCIALLY CONSIDERED.

A short description of the manufacture of farina has already been given in the chapter dealing with the starches. With a view to giving further details not necessarily of interest to sizers alone, the subject has been left to be more fully dealt with in the appendix. In the preparation of farina the following processes are involved. After careful washing, the potatoes are reduced to a fine pulp in a rasping machine. This pulp is afterwards washed through fine sieves, the starchy matter being carried in suspension in the washings and deposited in settling tanks as "raw starch." The raw starch contains various impurities, such as cellulose, albuminoids, fragments of potato, &c. By repeating the process, and using sieves, some of which have a revolving and others a horizontal motion, most of these impurities are removed and the milky liquor, after standing in settling tanks, deposits its starch. To hasten the separation of the starch small quantities of alum or of sulphuric acid are used. The former has, however, the disadvantage of coagulating the albumen and to that extent contaminating the starch, whilst the latter has a slight chemical action on the starch itself, and is also difficult of neutralisation. When the potatoes are more or less affected by

disease, or are touched by frost, great difficulty is experienced in effecting a speedy and a complete precipitation of the starch, and various reagents, such as bisulphite of lime, sulphurous acid, or caustic soda solution, may be called into use. Once freed from bacterial impurities, however, the usual routine may be followed.

After the starch has settled, the supernatant liquor is drawn off, and the starch re-washed. It is afterwards dried by means of a centrifugal washing machine and also by exposure to the air.

The stage is now reached at which either the process of conversion into dextrin (by the action of heat and the use of hydrochloric or nitric acid), or into glucose (starch-sugar) is entered upon, or the starch is ground up and further dried in a heated chamber.

Potatoes contain a variable quantity of starch, but, on the average, factory-potatoes (fabrikkartoffeln) contain 18 per cent., and by careful manipulation and good equipment 17 per cent. of dry starch (trockene stärke) can be obtained. Of this quantity about 14·5 parts will be commercial farina (of superior and prima qualities) and 2·5 parts will be by-products (schlammstärke and schlamm). The commercial article should not contain more than 20 per cent. (usually 17 to 20 per cent.) of moisture, and chemical examination shows it to contain about 0·2 to 0·5 per cent. of ash, 0·25 per cent. of albumen

and 0.055 per cent. of fatty matter. It should be free from acid, and practically free from specks (stippen), whether due to the presence of fragments of peel, chip, or fungoid growth. The size of the microscopic granules varies from 0.008 mm. in the lowest grades to 0.0355 mm. in the very highest grades of farina.

In the conversion into dextrin about 80 to 88 parts of dextrin are obtained from 100 parts of farina and the usual difference in price between the same firm's make of farina and dextrin is from £2 to £3 per ton. Chemically examined the commercial article may contain from 20 to 75 per cent. of dextrin (usually from 45 to 65 per cent.), this amount being frequently arranged to suit the requirements of the user. In water-free samples of dextrin as high as 80 per cent. of dextrin has been found in the commercial white dextrin, and as high as 97 per cent. in the yellow. The water contained is from 10 to 12 per cent., dextrose 2 to 7 per cent. (usually about 5 per cent.), ash 0.5 per cent., the balance consisting of unconverted starch. As to acidity, about 100 grams of dextrin usually require 3 c.c. (or from 1 to 6 c.c.) of normal alkali solution for neutralisation. Newly made yellow dextrin has a tender greenish undershade, but with age it turns reddish.

Farina is no longer made in England, but a variety of dextrin (known as "British Gum"),

manufactured from mixtures of starches (sago-flour, tapioca-flour, maize starch, and lower qualities of farina), is made in works chiefly situated in and around Manchester.

For the sake of comparison with the German potato crop statistics, given below, it may be of interest to state that for the period 1896-1900 the average British crop was 5,401,764 tons per annum (*i.e.*, about one-eighth the size of the German crop), whilst the yield per acre for the period 1890-99 was 4'59 tons.

THE GERMAN POTATO CROPS:—

Season.	Thousands of Acres under Cultivation.	Crop in Thousands of (English) Tons.	Tons per Acre.	Exports from Germany in tons.	
				Farina (and Potato Flour).	Dextrin.
1895	7,533	37,191	4'94	29,939	8,622
1896	7,540	31,820	4'22	33,402	10,851
1897	7,577	33,244	4'39	13,919	9,721
1898	7,609	36,142	4'75	17,055	7,958
1899	7,735	37,880	4'90	33,385	9,827
1900	7,950	39,946	5'02	21,449	10,007
1901	8,198	47,921	5'85	25,048	10,977
1902	8,004	42,778	5'34	45,237	13,827
1903	7,997	42,226	5'28	27,995	13,855
1904	8,121	35,716	4'40	17,262	11,936
1905	8,192	47,562	5'81	.....	.....

In 1897-8 the total quantity of German farina was 778,543 bags, and of dextrin 189,588 bags. Although, in this respect, official statistics of later date are not obtainable, it is believed that in

favourable years these figures are considerably exceeded, possibly by 50 per cent.

Farina is used more extensively as a sizing ingredient in Germany, taking into consideration the size of the cotton industry in that country, than in England, because sago-flour, tapioca-flour, and maize-starch are unable effectively to compete owing to the heavy import duties on these articles in the former country. The quantity of farina exported from Germany bears a variable relation to the quantity made there, being as much as 50 per cent. when prices are low, whilst it is much less when high prices rule. Of the exports of farina and dextrin from Germany the United Kingdom takes by far the largest quantity (sometimes more than one half), the next best customers being (in the order given).

(1) For farina:—Spain, America, Denmark, Italy, and Switzerland.

(2) For dextrin:—America, Austria-Hungary, Italy, Spain and Switzerland.

If we look at the question of British starch imports, we find, taking an average of years, about 89 per cent. come from three countries, viz., $37\frac{3}{4}$ per cent. from Germany, 26 per cent. from Holland, and $25\frac{1}{4}$ per cent. from U.S.A. Of the American supplies by far the greater part consists of maize starch, of the Dutch of farina (potato starch), and of the German of farina and rice starch,

About 85 to 90 per cent. of our imported dextrin comes from Germany, about 6 to 10 per cent. from Holland, and the remainder from U.S.A. and miscellaneous sources.

The relative importance of various countries as dextrin users is given to some extent by an analysis of the distribution of Germany's exports of dextrin. Great Britain $41\frac{1}{4}$ per cent., U.S.A. and Austria-Hungary each $13\frac{1}{2}$ per cent., Spain $5\frac{1}{2}$ per cent., Italy and Switzerland each $4\frac{3}{4}$ per cent. It should, however, be noted that this does not take into account the quantity of German-made dextrin used in Germany, whilst in U.S.A. maize starch dextrin is also used, and in England, besides the imported dextrans, a certain quantity of English-made dextrin and soluble starch (prepared from various starches and starch mixtures) is used.

As will already have been noticed from the foregoing table the acreage under potato cultivation in Germany during the last decade showed a gradual and constant increase up to 1901, when the greatest acreage was reached, and since which time there has been but slight variation. The yield per acre has also been much larger during the last quinquennium than in 1895-99, especially when it is considered that the low result in 1904 was due to very severe drought.

Two-thirds of the area under potatoes is in Prussia (chiefly in the provinces of Schlesien.

Brandenburg, Posen, and Pomerania). Outside Prussia the most important potato districts are Bavaria, Saxony, and Wütemberg. According to Dr. Behrend ("Deutschlands Kartoffelerzeugung und Verbrauch in Gegenwart und Zukunft") the distribution of a German potato crop, of say 43 million tons, would be about as follows:—

Manufacture of Potato Spirit	... ..	2'5	million tons
Manufacture of Farina and of Farina			
Products (Dextrin, Glucose, &c.)	1'4		"
Used for Seed purposes	... ..	5'2	"
Loss by Disease (10 per cent.)	... ..	4'3	"
Human Consumption...	... ..	12'0	"
Pig-feeding, &c.	... ..	17'6	"

The shipments of farina and dextrin to this country are usually much the heaviest in October and November, not only on account of the dwindling of old stocks at the various distributing centres but also that towards the end of November internal navigation is often interfered with in Germany and Holland by ice, involving higher internal freight charges. The makers are also then working at high pressure on the new season's produce, and are anxious to dispose of a good portion of their manufactured products as early as possible. A good proportion of the users in this country contract for their year's requirements when the new season's price of the B.K.M.F. farina (a mark of farina made originally in Baden, but now at Cüstrin, in Prussia), and other equally well-known marks of

farina are quoted, usually some time in October (or in November, when the crop is late), as, by that time, the result of the crop is almost assured, providing severe frost does not set in and cause a smart advance, as in 1902, or disease does not manifest itself, especially in the potatoes stored in pits for the winter.

Taking a number of years with cheap autumn prices it may be stated (almost as a general rule) that the prices in March, and later months, show a very considerable advance (as in 1887, 1897, 1901, 1902, &c.). The converse proposition that high autumn prices are followed by lower spring prices obtained in 1871, 1888, 1891, &c., but cannot be relied upon to the same extent. In this connection the attention of the reader may be drawn to the following deductions from a chart published by the "Deutschen Stärkeverkaufsgenossenschaft," in Berlin, in 1905, showing the fluctuations in the price of "Prima" farina in the Berlin starch market since 1860. From this chart it appears that the highest and lowest prices touched were from 44·5 marks in December, 1871, to just over 14 marks in November-December, 1895, the highest price being more than three times the lowest. Great variations in price of 10 or even 15 marks (*i.e.*, £5 to £7 10s. per ton) have taken place within very short periods. Thus between August and December, 1871, the price rose from 29·5 marks to 44·5 marks, and between July

and December, 1892, it declined from 36 marks to 18 marks per sack. Maximum prices have usually obtained during the winter months, November to March; thus, in February, 1861, 40 m.; January, 1868, 39'5 m.; December, 1871, 44'5 m.; March, 1880, 36 m.; December, 1891, nearly 38 m.; the prices were much higher than in the preceding and following months. Price-minima have also shown a predilection for the winter months, as in the seasons 1884-5, 1885-6, 1893-4, 1895-6. It also appears that low prices have ruled for longer periods and with smaller fluctuations than when high prices obtained. Taking quinquennial periods we see that the general tendency has been for lower prices and smaller fluctuations:—

Period.	Minimum Price.	Maximum Price.
1860-1865	23'0 Marks.	40'0 Marks.
1865-1870	23'5 "	39'5 "
1870-1875	24'1 "	44'5 "
1875-1880	24'2 "	32'0 "
1880-1885	16'5 "	36'0 "
1885-1890	16'0 "	28'6 "
1890-1895	16'2 "	37'7 "
1895-1900	14'3 "	26'8 "
1900-1905	14'8 "	28'2 "

DUTCH FARINA.

It is remarkable how widespread potato culture is in Holland, 158,732 hectares (*i.e.*, 392,068 acres) out of a total of 931,834 hectares (1 hectare = 2'47

acres) being under potatoes in 1904, and of these 26,529 hectares (or 65,527 acres) were devoted to the culture of fabrik-hartoffeln, *i.e.*, potatoes intended for the manufacture of farina, dextrin and glucose. The acreage under factory potatoes in 1905 was 29,714 hectares, and in 1906, 27,238 hectares. Taking all Holland in 1904, the crop was 2,063,252 English tons, or $5\frac{1}{4}$ tons per acre, whilst for factory potatoes it was 604,719 tons, or 9.20 tons per acre. Under the most favourable conditions and in isolated areas, a yield of as much as nearly 16 tons per acre (40,000 kilos pro hectar) has been obtained.

The districts chiefly devoted to the cultivation of factory potatoes are known as the "Veenkolonien," or turf colonies, of Groningen and Drenthe. The land was formerly an extensive peat-bog, which was only with difficulty brought under cultivation by draining the land by means of deep canals and trenches, stripping the surface of peat (for fuel) and suitably manuring the underlying soil. These tracts are known as "Hohe Veenen," or high fens. The turf-cutting was begun on a small scale at Groningen in the eleventh and twelfth centuries, but the commencement of the first colonies and the cultivation of the peat-stripped areas dates from the thirteenth and fourteenth centuries, the turf being sent in boats down to Groningen, and there sold for fuel, whilst the town manure was sent back gratis, and in 1848 the town even forbade its

going elsewhere. Later, however, the town sold the Kompost to the settlers, and from 1862 to 1878 the sale brought in 27,000 florins yearly. This form of manuring has now given place to a more elaborate and scientific system, and to-day the turf-boats go back empty. In the eighteenth and up to the middle of the nineteenth century the culture of corn, rape-seed, and mustard, were the most important, but since then potato-culture has been the most important branch of agriculture, and potatoes have been exported from the Veen-colonies since 1778.

Distilleries for potato-spirit were started but did not prosper in the land of gin, and Holland kept to its corn distilleries. The first Dutch farina factory was that started in Muntendam by J. A. Boon in 1840, but it was short-lived. He was followed shortly afterwards by W. A. Scholton, and then by numerous others. In fact so keen became the rivalry among the farina-makers to secure the potatoes that the growers very greatly profited, and ultimately this led to the formation of the "Eureka" potato-buying combine (Eureka Verkoopscantor Ardappelmeel), which, from the start, met with the antipathy of the growers, as they had to deliver at a price fixed by the "Eureka." Enterprising growers, therefore, combined in self-defence and formed the first Co-operative Ardappelmeelfabrik, which was followed by other co-operative mills owned by the growers, who supplied them with the potatoes, until

to-day there are some 32 factories (private, company and co-operative mills), the majority new, well-equipped, and capable of dealing with a large quantity of potatoes. In 1904, some 87,894 (English) tons of farina were made in Holland, of which 68,745 tons were exported. (In addition to farina, some factories also manufacture dextrin and glucose). This vast quantity of farina is bought by the United Kingdom, the United States, Belgium, Spain, Italy, Scandinavia, and the Colonies. It may be remarked here, that most of the farina sent to India goes by Liverpool, and through the medium of English merchants. The superior qualities made by the best of the Dutch factories are now so pure and good as scarcely to leave room for further improvement, whilst the old drawback to the use of Dutch farina—its high percentage of moisture, often over 24 per cent.—has been done away with by the adoption of improved methods, and a percentage of even 20 per cent. is now rarely met with, except sometimes at the opening of the new season.

SAGO FLOUR.

The average monthly consumption of sago flour in Lancashire in 1903 was about 1,190 tons; in 1904 1,251 tons; and in 1905, 1,357 tons.

APPENDIX B.

New Process of Cotton Dyeing.

THERE is a great demand for a more uniform colour in dyed cotton than can be produced either by dyeing in the piece or by dyeing in the form of hanks, cops or bobbins.

There is no doubt that until recently the best results were obtained by dyeing raw cotton, but this process is economically unsatisfactory for several reasons. In the first place all the waste cotton and the dust and dirt is dyed, and in the second place the coloured waste is practically unsaleable.

The best stage in which the dyeing can be carried out is whilst the cotton is in the form of "sliver." In this stage only that cotton which will be spun into yarn is treated and there is therefore no waste of dye stuff.

As far as the minutest tests can be made it has been shown that "sliver" dyeing produces an absolutely perfect and uniform colour in the thread,

which is far in advance of any other form of dyeing. Every fibre is dyed through, and whether the yarn has to be woven into plain self-coloured cloth or used for borders and headings, the shade is perfect.

The process of "sliver" dyeing has been perfected, after many years of experiments, by Mr. Dan Scholefield, who has had over 50 years' experience as a practical dyer. It is past the experimental stage, and there is no process to compare with it for economy, simplicity, and uniformity of shade, and there is no difficulty in the spinning operations after dyeing.

The dyeing machine is simple in construction, and there is nothing to get out of order.

The possibilities of "sliver" dyeing have been greatly increased by the introduction of the sulphur colours, and by the introduction of the hyposulphite-soda vat process of indigo dyeing. These valuable additions to the dyes employed for cotton are specially applicable to "sliver" dyeing.

Practically every description of dyeing can be carried out by the processes, but the following are the most suitable classes of colours to employ:—Direct colours, sulphur colours and indigo.

From what has been said it will be apparent that this is a process of dyeing which can be carried out by the cotton spinner only and not by the dyer of hanks or piece goods.

The process does not require any special training on the part of the spinner as it is absolutely mechanical after the machine is working.

It will be at once appreciated by the spinner how evenness of shade can be got in the spun yarn. If there is any variation in one batch of dyed "slivers," the next lot can be dyed darker or lighter as required. As it is customary to draw from six cans at the first draw frame, perfect evenness of shade can be produced in the final spinning.

APPENDIX C.

*Table comparing Beaume
and Twaddell with Specific Gravity
together with
Percentage Table of Common Chemicals.*

Beaume.	Twaddell.	Specific Gravity.	PERCENTAGE OF				
			Sul- phuric Acid.	Spirits of Salts.	Nitric Acid.	Caustic Soda Na OH.	SO ₂ in Sodium Bisul- phite.
0	0	1,000	0·9	0·1	0·2	0	
1	1·4	1,007	1·9	1·5	1·5	0·61	0·4
2	2·8	1,014	2·8	2·9	2·6	1·20	0·85
3	4·4	1,022	3·8	4·5	4·0	2·00	1·3
4	5·8	1,029	4·8	5·8	5·1	2·71	1·75
5	7·4	1,037	5·8	7·3	6·3	3·35	2·2
6	9·0	1,045	6·8	8·9	7·6	4·00	2·65
7	10·2	1,052	7·8	10·4	9·0	4·64	3·1
8	12·0	1,060	8·8	12·0	10·2	5·29	3·5
9	13·4	1,067	9·8	13·4	11·4	5·87	3·9
10	15·0	1,075	10·8	15·0	12·7	6·55	4·35
11	16·6	1,083	11·9	16·5	14·0	7·31	4·8
12	18·2	1,091	13·0	18·1	15·3	8·00	5·25
13	20·0	1,100	14·1	19·9	16·8	8·68	5·7
14	21·6	1,108	15·2	21·5	18·0	9·42	6·25
15	23·2	1,116	16·2	23·1	19·4	10·06	6·8
16	25·0	1,125	17·3	24·8	20·8	10·97	7·3
17	26·8	1,134	18·5	26·6	22·2	11·84	7·8
18	28·4	1,142	19·6	28·4	23·6	12·64	8·4
19	30·4	1,152	20·8	30·2	24·9	13·55	9·0
20	32·4	1,162	22·2	31·2	26·3	14·37	9·6
21	34·2	1,171	23·3	32·0	27·8	15·13	10·2
22	36·0	1,180	24·5	33·0	29·2	15·91	10·85
23	38·0	1,190	25·8	33·9	30·7	16·77	11·5
24	40·0	1,200	27·1	34·7	32·1	17·67	12·2
25	42·0	1,210	28·4	35·7	33·8	18·58	12·9
26	44·0	1,220	29·6	36·8	35·5	19·58	13·7
27	46·2	1,231	31·0	37·9	37·0	20·59	14·5
28	48·2	1,241	32·2	39·0	38·6	21·42	15·2
29	50·4	1,252	33·4	39·8	40·2	22·64	15·9

Table comparing Beaume and Twaddell with
Specific Gravity together with
Percentage Table of Common Chemicals.
Continued.

Beaume.	Twaddell.	Specific Gravity	PERCENTAGE OF				
			Sul-phuric Acid.	Spirits of Salts.	Nitric Acid.	Caustic Soda Na OH	SO ₂ in Sodium Bisul-phite.
30	52·6	1,263	34·7	41·2	41·5	23·67	16·85
31	54·8	1,274	36·0	42·4	43·5	24·81	17·8
32	57·0	1,285	37·4	42·9	45·0	25·80	18·7
33	59·4	1,297	38·8		47·1	26·83	19·6
34	61·6	1,308	40·2		48·6	27·80	21·0
35	64·0	1,320	41·6		50·7	28·83	22·5
36	66·4	1,332	43·0		52·9	29·93	23·0
37	69·0	1,345	44·4		55·0	31·22	23·6
38	71·4	1,357	45·5		57·3	32·47	
39	74·0	1,370	46·9		59·6	33·69	
40	76·6	1,383	48·3		61·7	34·96	
41	79·4	1,397	49·8		64·5	36·25	
42	82·0	1,410	51·2		67·5	37·47	
43	84·8	1,424	52·8		70·6	38·80	
44	87·6	1,438	54·0		74·4	39·99	
45	90·6	1,453	55·4		78·4	41·41	
46	93·6	1,468	56·9		83·0	42·83	
47	96·6	1,483	58·3		87·1	44·38	
48	99·6	1,498	59·6		92·6	46·15	
49	103·0	1,514	61·0		96·0	47·60	
50	106·0	1,530	62·5		98·0	49·02	
51	109·2	1,540	64·0		100·0		
52	112·6	1,563	65·5				
53	116·0	1,580	67·0				
54	119·4	1,597	68·0				
55	123·0	1,615	70·0				
56	127·0	1,634	71·6				
57	130·0	1,652	73·2				
58	134·0	1,672	74·7				
59	138·2	1,691	76·4				
60	142·0	1,711	78·1				
61	146·4	1,732	79·0				
62	150·6	1,753	81·7				
63	155·0	1,774	84·1				
64	159·0	1,796	86·5				
65	164·0	1,819	89·7				
66	168·4	1,840	96·0				

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